CHAPTER 4

SITE-SPECIFIC INDUSTRIAL STORM WATER BMPs

This chapter describes some of the possible Best Management Practices (BMPs) that you might include in your Storm Water Pollution Prevention Plan so that pollutants from your site do not mix with storm water.

Table 4.1 provides an easy index of the BMP descriptions that follow. The BMPs are grouped by section into six categories: Flow Diversion Practices; Exposure Minimization Practices; Mitigative Practices; Other Preventive Practices; Sediment and Erosion Prevention Practices; and Infiltration Practices.

The following information is provided for each BMP: (1) description of the BMP; (2) when and where the BMP can be used; (3) factors that should be considered when using the BMP; and (4) advantages and disadvantages of the BMP. More detailed fact sheets for a limited number of the Sediment and Erosion Prevention Practices are included as Appendix E. When designing these structural controls, EPA recommends that you refer to any State or local storm water management design standards.

TABLE 4.1 INDEX OF SITE-SPECIFIC INDUSTRIAL STORM WATER BMPs

TABLE 4.1 INDEX OF SITE-SPECIFIC INDUSTRIAL STORM WATER BMPs (Continued)

4.1 FLOW DIVERSION PRACTICES

Structures that divert stream flow (such as gutters, drains, sewers, dikes, and graded pavement) are used as BMPs in two ways. First, flow diversion structures, called storm water conveyances, may be used to channel storm water away from industrial areas so that pollutants do not mix with the storm water. Second, they also may be used to carry pollutants directly to a treatment facility. This section briefly describes flow diversion as a BMP for industrial storm water.

Storm Water Conveyances (Channels/Gutters/Drains/Sewers)

What Are They

Storm water conveyances such as channels, gutters, drains, and sewers, collect storm water runoff and direct its flow. A group of connecting conveyances is sometimes installed at an industrial facility to create a storm water collection system. Storm water conveyances can be used for two different purposes. The first purpose is to keep uncontaminated storm water from coming in contact with areas of an industrial site where it may become contaminated with pollutants. This can be accomplished by collecting the storm water in a conveyance and by changing the direction of flow away from those areas. The second purpose is to collect and carry the storm water that has already come into contact with industrial areas and become contaminated to a treatment facility.

Storm water conveyances can be constructed or lined with many different materials, including concrete, clay tiles, asphalt, plastics, metals, riprap, compacted soils, and vegetation. The type of material used depends on the use of the conveyance. These conveyances can be temporary or permanent.

When and Where to Use Them

Storm water conveyances work well at most industrial sites. Storm water can be directed away from industrial areas by collecting it in channels or drains before it reaches the areas. In addition, conveyances can be used to collect storm water downhill from industrial areas and keep it separate from runoff that has <u>not</u> been in contact with those areas. When potentially contaminated storm water is collected in a conveyance like this, it can be directed to a treatment facility on the site if necessary. (If a pollutant is spilled, it should not be allowed to enter a storm water conveyance or drain system.)

What to Consider

In planning for storm water conveyances, consider the amount and speed of the typical storm water runoff. Also, consider the patterns in which the storm water drains so that the channels may be located to collect the most flow and can be built to handle the amount of water they will receive. When deciding on the type of material for the conveyance, consider the resistance of the material, its durability, and compatibility with any pollutants it may carry.

Conveyance systems are most easily installed when a facility is first being constructed. Use of existing grades will decrease costs. Grades should be positive to allow for the continued movement of the runoff through the conveyance system; however, grades should not create an increase in velocity that causes an increase in erosion (this will also depend upon what materials the conveyance is lined with and the types of outlet controls that are provided).

Ideally, storm water conveyances should be inspected to remove debris within 24 hours of rainfall, or daily during periods of prolonged rainfall, since heavy storms may clog or damage them. It is important to repair damages to these structures as soon as possible.

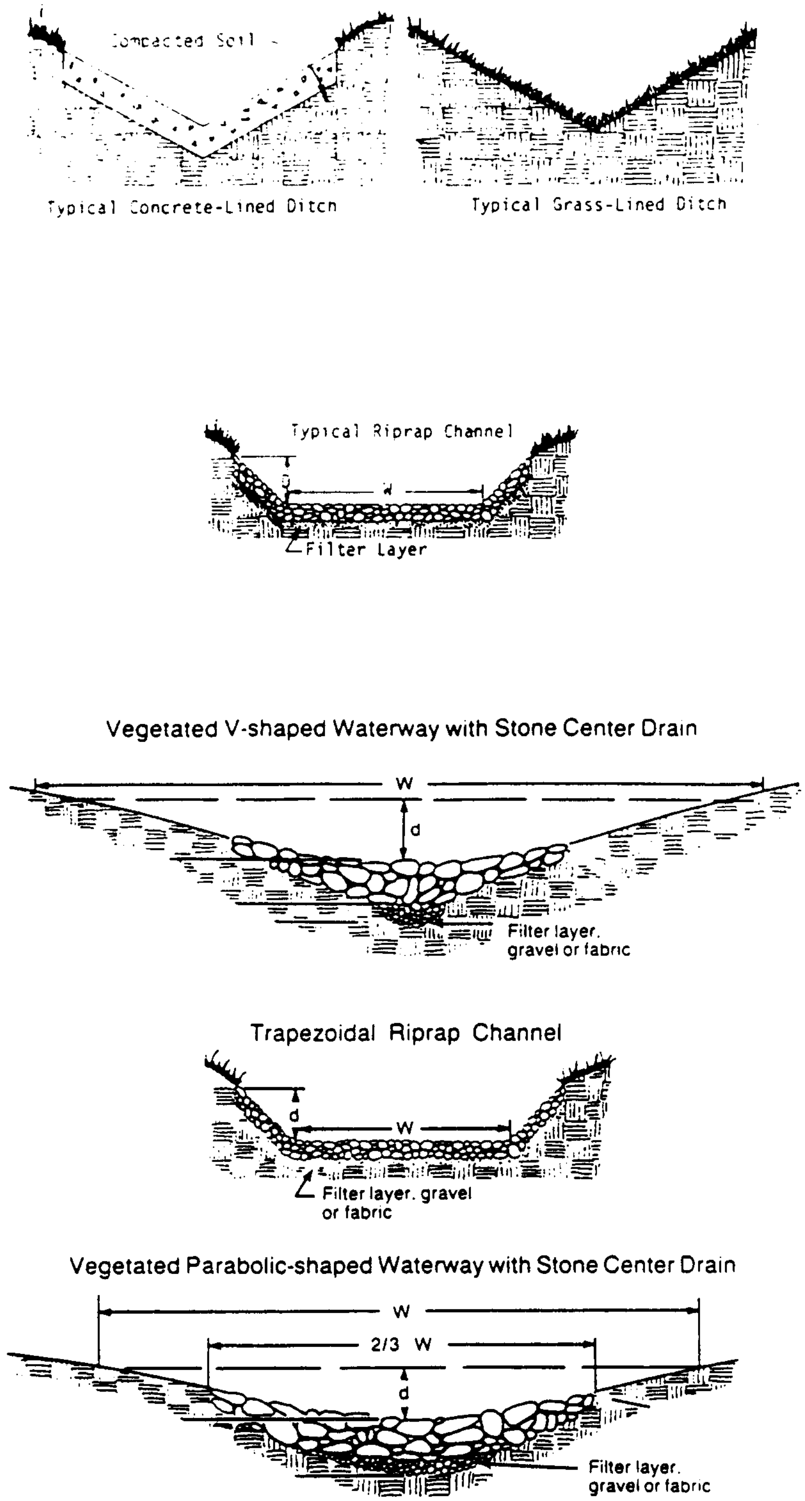


FIGURE 4.1 TYPICAL STORM WATER CONVEYANCE CROSS SECTIONS (Modified from Commonwealth of Virginia, 1980)

Advantages of Storm Water Conveyances (Channels/Gutters/Drains/Sewers)
• Direct storm water flows around industrial areas • Prevent temporary flooding of industrial site • Require low maintenance • Provide erosion resistant conveyance of storm water runoff • Provide long-term control of storm water flows

Disadvantages of Storm Water Conveyances (Channels/Gutters/Drains/Sewers)
• Once flows are concentrated in storm water conveyances, they must be routed through stabilized structures all the way to their discharge to the receiving water or treatment plant to minimize erosion • May increase flow rates • May be impractical if there are space limitations • May not be economical, especially for small facilities or after a site has already been constructed

Diversion Dikes

What Are They

Diversion dikes or berms are structures used to block runoff from passing beyond a certain point. Temporary dikes are usually made with compacted soil. More permanent ridges are constructed out of concrete, asphalt, or similar materials.

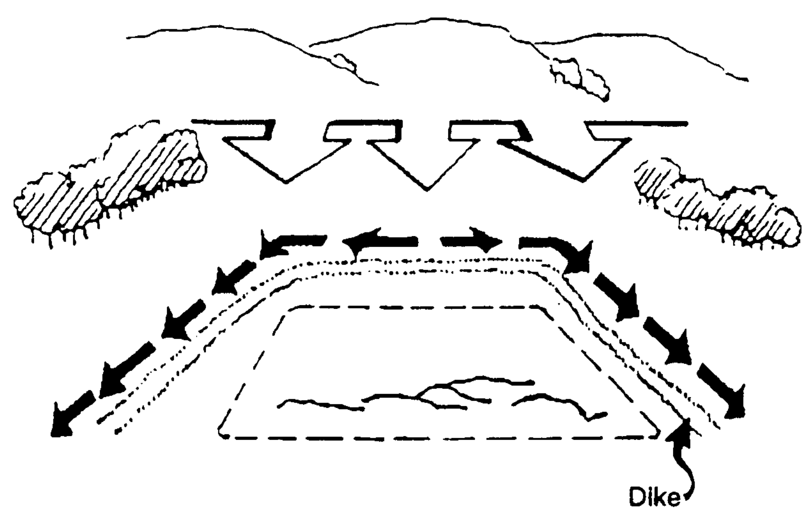


FIGURE 4.2 DIVERSION DIKES
(Modified from North Carolina, 1988)

When and Where to Use Them

Diversion dikes are used to prevent the flow of storm water runoff onto industrial areas. Limiting the volume of flow across industrial areas reduces the volume of storm water that may carry pollutants from the area, requiring treatment for pollutant removal. This BMP is suitable for industrial sites where significant volumes of storm water runoff tend to flow onto active industrial areas. Typically, dikes are built on slopes just uphill from an industrial area together with some sort of a conveyance such as a swale. The storm water conveyance is necessary to direct the water away from the dike so that the water will not pool and seep through the dike.

What to Consider

In planning for the installation of dikes, consider the slope of the drainage area, the height of the dike, the size of rainfall event it will need to divert, and the type of conveyance that will be used with the dike. Steeper slopes result in higher volumes of runoff and higher velocities; therefore, the dike must be constructed to handle this situation. Remember that dikes are limited in their ability to manage large volumes of runoff.

Ideally, dikes are installed before industrial activity begins. However, dikes can be easily constructed at any time. Temporary dikes (usually made of dirt) generally only last for 18 months or less, but they can be made into permanent structures by stabilizing them with vegetation. Vegetation is crucial for preventing the erosion of the dike.

Dikes should be inspected regularly for damage. This is especially important after storm events since a heavy rain may wash parts of a temporary dike away. Any necessary repairs should be made immediately to make sure the structure continues to do its job.

Advantages of Diversion Dikes
• Effectively limit storm water flows over industrial site areas • Can be installed at any time • Are economical temporary structures, when built from soil onsite • Can be converted from temporary to permanent at any time
Disadvantages of Diversion Dikes
• Are not suitable for large drainage areas unless there is a gentle slope • May require maintenance after heavy rains

Graded Areas and Pavement

What Is It

Land surfaces can be graded or graded and paved so that storm water runoff is directed away from industrial activity areas. The slope of the grade allows the runoff to flow, but limits the runoff from washing over areas that may be contaminated with pollutants. Like conveyances and dikes, graded areas can prevent runoff from contacting industrial areas and becoming contaminated with pollutants from these areas. Grading can be a permanent or temporary control measure.

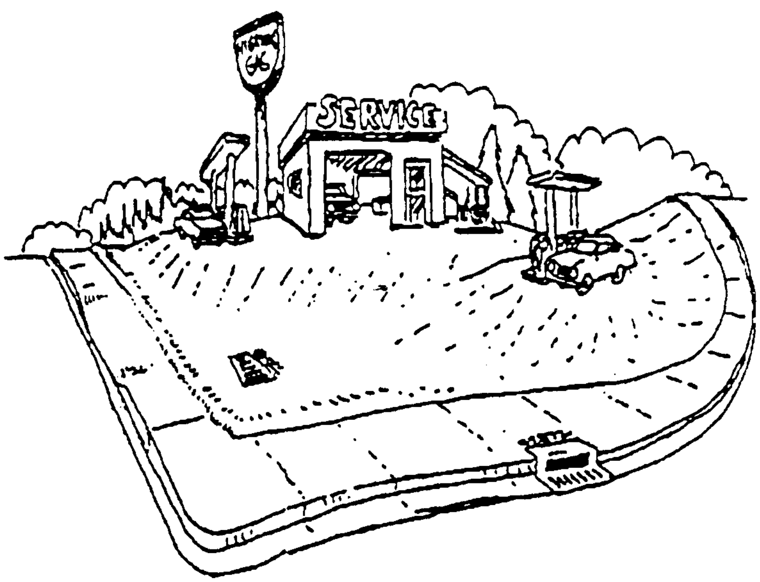


FIGURE 4.3 EXAMPLE OF GRADED PAVEMENT
(Modified from Santa Clara Valley, 1990)

When and Where to Use It

Grading land surfaces is appropriate for any industrial site that has outdoor activities that may contaminate storm water runoff, such as parking lots or outdoor storage areas. Figure 4.3 illustrates the use of graded pavement in preventing runoff from washing over a service station site. Grading is often used with other practices, such as coverings, buffer zones, and other practices to reduce the runoff velocity and provide infiltration of the uncontaminated runoff, or to direct pollutant runoff to storm water treatment facilities.

What to Consider

When designing graded areas and pavement, both control and containment of runoff flows should be considered. The grading should control the uncontaminated flow by diverting it around areas that may have pollutants. The grading should also contain the contaminated flows or divert them to treatment facilities.

When regrading and paving an industrial area, the use of concrete paving instead of asphalt should be considered. This is especially important in potential spill sites or hazardous material storage areas. Asphalt absorbs organic pollutants and can be slowly dissolved by some fluids, thus becoming a possible source of contaminants itself. This control measure should be used with a cover, such as a roof, in areas where contaminants are of concern (see Covering BMP) so that rain or snow does not fall on the area and wash the contaminants down slope.

Inspect paving regularly for cracks that may allow contaminants to seep into the ground. Also, check to make sure that the drains receiving the storm water flow from the paved area remain unclogged with sediment or other debris so that low areas do not flood and wash over the areas where the contaminants may be.

Advantages of Graded Areas and Pavement
• Is effective in limiting storm water contact with contaminants • Is relatively inexpensive and easily implemented
Disadvantages of Graded Areas and Pavement
• May be uneconomical to regrade and resurface large areas • May not be effective during heavy precipitation

4.2 EXPOSURE MINIMIZATION PRACTICES

By eliminating or minimizing the possibility of storm water coming into contact with pollutants, facilities can eliminate or minimize the contamination of storm water discharges associated with their industrial activity. As a result, fewer materials will be carried away by storm water runoff, the costs of collecting and treating contaminated storm water will be decreased, and safety and environmental liabilities that result from spills and leaks will be reduced.

Completely eliminating the exposure of materials to storm water is not always possible, however. For many industrial facilities, enclosure of facility grounds is not technologically or economically possible. Therefore, this section describes several simple and inexpensive structural and nonstructural BMPs that a facility can use to minimize the exposure of materials to storm water.

Containing spills is one of the primary methods of minimizing exposure of contaminants to storm water runoff. Spill containment is used for enclosing any drips, overflows, leaks, or other liquid material releases, as well as for isolating and keeping pollutant spills away from storm water runoff.

There are numerous spill containment methods, ranging from large structural barriers to simple, small drip pans. The benefits of each of these practices vary based on cost, need for maintenance, and size of the spill they are designed to control. This section describes several containment methods, including:

- Containment Diking
- Curbing
- Drip Pans
- Catch Basins
- Sumps.

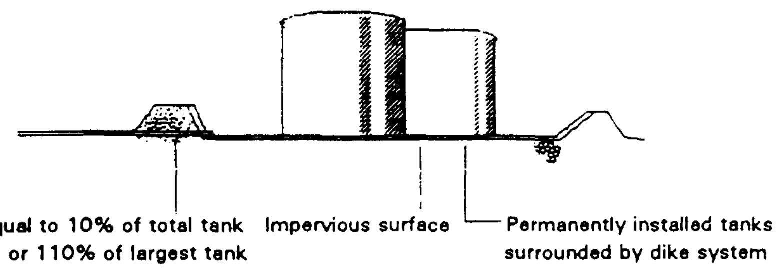
Other practices commonly used to minimize exposure of contaminants are also discussed, including the following:

- Covering
- Vehicle Positioning
- Loading and Unloading by Air Pressure or Vacuum.

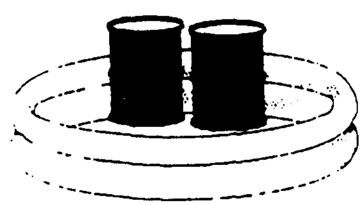
Containment Diking

What Is It

Containment dikes are temporary or permanent earth or concrete berms or retaining walls that are designed to hold spills. Diking, one of the most common types of containment, is an effective method of pollution prevention for above-ground liquid storage tanks and rail car or tank truck loading and unloading areas. Diking can provide one of the best protective measures against the contamination of storm water because it surrounds the area of concern and holds the spill, keeping spill materials separated from the storm water outside of the diked area.



Containment Diking for Large Storage Areas



Containment Diking for Small Storage Areas

FIGURE 4.4 CONTAINMENT DIKING
(Modified from MWCOG, 1992)

When and Where to Use It

Diking can be used at any industrial facility but is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas.

What to Consider

Containment dikes should be large enough to hold an amount equal to the largest single storage tank at the particular facility plus the volume of rainfall. For rail car and tank truck loading and unloading operations, the diked area should be capable of holding an amount equal to any single tank truck compartment. Materials used to construct the dike should be strong enough to safely hold spilled materials. The materials used usually depend on what is available onsite and the substance to be contained, and may consist of earth (i.e., soil or clay), concrete, synthetic materials (liners), metal, or other impervious materials. In general, strong acids and bases may react with metal containers, concrete, and some plastics, so where spills may consist of these substances, other alternatives should be considered. Some of the more reactive organic chemicals may also need to be contained with special liners. If there are any questions about storing chemicals in certain dikes because of their construction materials, refer to the Material Safety Data Sheets (MSDSs).

Containment dikes may need to be designed with impervious materials to prevent leaking or contamination of storm water, surface, and ground water supplies.

Similarly, uncontrolled overflows from diked areas containing spilled materials or contaminated storm water should be prevented to protect nearby surface waters or ground waters. Therefore, dikes should have either pumping systems (see Sumps BMP) or vacuum trucks available to remove the spilled materials. When evaluating the performance of the containment system, you should pay special attention to the overflow system, since it is often the source of uncontrolled leaks. If overflow systems do not exist, accumulated storm water should be released periodically. Contaminated storm water should be treated prior to release. Mechanical parts, such as pumps or even manual systems (e.g., slide gates, stopcock valves), may require regular cleaning and maintenance.

When considering containment diking as a BMP, you should consult local authorities about any regulations governing construction of such structures to comply with local and State requirements. Facilities located in a flood plain should contact their local flood control authority to ensure that construction of the dikes is permitted.

Inspections of containment dikes should be conducted during or after significant storms or spills to check for washouts or overflows. In addition, regular checks of containment dikes (i.e., testing to ensure that dikes are capable of holding spills) is recommended. Soil dikes may need to be inspected on a more frequent basis.

Changes in vegetation, inability of the structure to retain storm water dike erosion, or soggy areas indicate problems with the dike's structure. Damaged areas should be patched and stabilized immediately, where necessary. Earthen dikes may require special maintenance of vegetation, such as mowing and irrigation.

Advantages of Containment Diking
• Contains spills, leaks, and other releases and prevent them from flowing into runoff conveyances, nearby streams, or underground water supplies • Permits materials collected in dikes to be recycled • Is a common industry practice for storage tanks and already required for certain chemicals
Disadvantages of Containment Diking
• May be too expensive for some smaller facilities • Requires maintenance • Could collect contaminated storm water, possibly resulting in infiltration of storm water to ground water

Curbing

What Is It

Like containment diking, curbing is a barrier that surrounds an area of concern. Curbing functions in a similar way to prevent spills, leaks, etc. from being released to the environment by routing runoff to treatment or control areas. The terms curbing and diking are sometimes used interchangeably.

Because curbing is usually small-scale, it cannot contain large spills like diking can, however, curbing is common at many facilities in small areas where handling and transferring liquid materials occur.

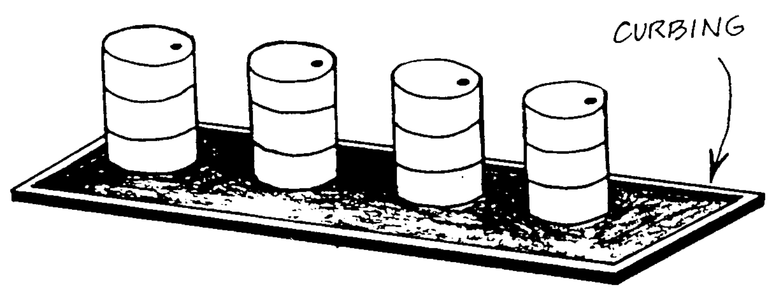


FIGURE 4.5 CURBING AROUND DRUM STORAGE AREA

When and Where to Use It

Curbing can be used at all industrial facilities. It is particularly useful in areas where liquid materials are transferred and as a storm water runoff control.

As with diking, common materials for curbing include earth, concrete, synthetic materials, metal, or other impenetrable materials. Asphalt is also a common material used in curbing.

What to Consider

For maximum efficiency of curbing, spilled materials should be removed immediately, to allow space for future spills. Curbs should have pumping systems, rather than drainage systems, for collecting spilled materials. Manual or mechanical methods, such as those provided by sump systems (see Sump BMP), can be used to remove the material. Curbing systems should be maintained through curb repair (patching and replacement).

When using curbing for runoff control, facilities should protect the berm by limiting traffic and installing reinforced berms in areas of concern.

Spills of materials that are stored within a curbed area can be tracked outside of that area when personnel and equipment leave the area. This tracking can be minimized by grading within the curbing to direct the spilled materials to a down-slope side of the curbing. This will keep the materials away from personnel and equipment that pass through the area. It will also allow the materials to accumulate in one area making cleanup much easier.

Inspections should also be conducted before forecasted rainfall events and immediately after storm events. If spilled or leaked materials are observed, cleanup should start immediately. This will prevent overflows and/or contamination of storm water runoff. In addition, prompt cleanup of materials will prevent dilution by rainwater, which can adversely affect recycling opportunities. Inspection of curbed areas should be conducted regularly, to clear clogging debris. Because curbing is sized to contain small spill volumes, maintenance should also be conducted frequently to prevent overflow of any spilled materials.

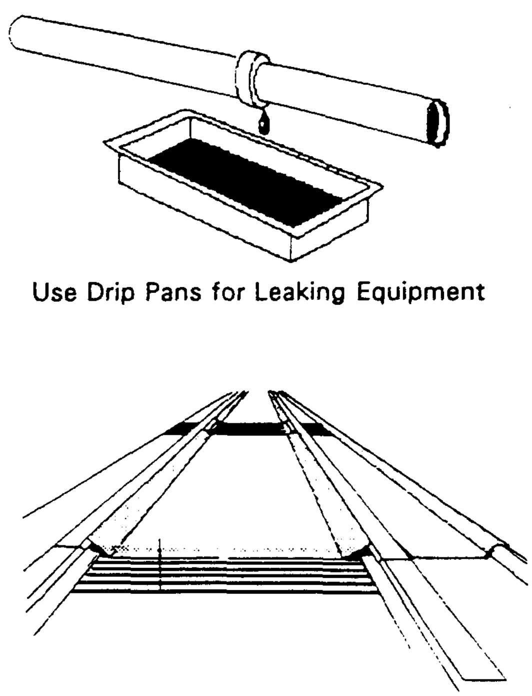
Advantages of Curbing
• Is an excellent method to control runon • Is inexpensive • Is easily installed • Materials spilled within curbed areas can be recycled • Exists as a common industry practice
Disadvantages of Curbing
• Is not effective for holding large spills • May require more maintenance than diking

Drip Pans

What Are They

Drip pans are small depressions or pans used to contain very small volumes of leaks, drips, and spills that occur at a facility. Drip pans can be depressions in concrete, asphalt, or other impenetrable materials or they can be made of metals, plastic, or any material that does not react with the dripped chemicals. Drip pans can be temporary or permanent.

Drip pans are used to catch drips from valves, pipes, etc. so that the materials or chemicals can be cleaned up easily or recycled before they can contaminate storm water. Although leaks and drips should be repaired and eliminated as part of a preventive maintenance program, drip pans can provide a temporary solution where repair or replacement must be delayed. In addition, drip pans can be an added safeguard when they are positioned beneath areas where leaks and drips <u>may</u> occur.



Use Drip Pans for Leaking Equipment

Use Drip Pans in Loading and Unloading Areas

FIGURE 4.6 USES FOR DRIP PANS
(Modified from Washington State, 1992)

When and Where to Use Them

Drip pans can be used at any industry where valves and piping are present and the potential for small volume leakage and dripping exist.

What to Consider

When using drip pans, consider the location of the drip pan, weather conditions, the type of material to be used for the drip pan, and how it will be cleaned.

The location of the drip pan is important. Because drip pans must be inspected and cleaned frequently, they must be easy to reach and remove. In addition, take special care to avoid placing drip pans in precarious positions such as next to walkways, on uneven pavement/ground, or sitting on pipelines. Drip pans in these locations are easily overturned and may present a safety hazard, as well as an environmental hazard.

Weather conditions are also important factors. Heavy winds and rainfall move or damage drip pans because of their small size and their light weight (if not built-in). To prevent this, secure the pans by installing or anchoring them. Drip pans may be placed on platforms or behind wind blocks or tied down.

For drip pans to be effective, employees must pay attention to the pans and empty them when they are nearly full. Because of their small holding capacities, drip pans will easily overflow if not emptied. Also, recycling efforts can be affected if storm water accumulates in drip pans and dilutes the spilled material. It is important to have clearly specified and easily followed practices of reuse/recycle and/or disposal, especially the disposal of hazardous materials. Many facilities dump the drip pan contents into a nearby larger volume storage container and periodically recycle the contents of the storage container.

In addition, frequent inspection of the drip pans is necessary due to the possibility of leaks in the pan itself or in piping or valves that may occur randomly or irregular slow drips that may increase in volume. Conduct inspections before forecasted rainfall events to remove accumulated materials and immediately after storm events to empty storm water accumulations.

Advantages of Drip Pans
• Are inexpensive • Are easily installed and simple to operate • Allow for reuse/recycle of collected material • Empty or discarded containers may be reused as drip pans
Disadvantages of Drip Pans
• Contain small volumes only • Must be inspected and cleaned frequently • Must be secured during poor weather conditions • Contents may be disposed of improperly unless facility personnel are trained in proper disposal methods

Collection Basins

What Are They

Collection basins, or storage basins, are permanent structures where large spills or contaminated storm water are contained and stored before cleanup or treatment. Collection basins are designed to receive spills, leaks, etc. that may occur and prevent these materials from being released to the environment. Unlike containment dikes, collection basins can receive and contain materials from many locations across a facility.

Collection basins are commonly confused with treatment units such as ponds, lagoons, and other containment structures. Collection basins differ from these structures because they are designed to temporarily store storm water rather than treat it.

When and Where to Use Them

Collection basins are appropriate for all industrial sites where space allows. Collection basins are particularly useful for areas that have a high spill potential.

What to Consider

The design and installation considerations for collection basins include sizing the basin either to hold a certain amount of spill or a certain size storm, or both. In designing the collection system, the type of material for the conveyances, compatibility of various materials to be carried through the system, and requirements for compliance with State and local regulations should be considered. Ideally, the system should function to route the materials quickly and easily to the collection basin.

When spills occur, the collection system must route the spill or storm water immediately to the collection basin. After a spill is contained, the collection system and basin may require cleaning. Remove the collection basin contents immediately to prevent an unintentional release and recycle the spilled material as much as possible. Inspect the structure on a regular basis and after storm events or spills. Depending upon the types of pollutants that may be in the storm water, or are collected as spills, design of the basin may require a liner to prevent infiltration into the ground water. Make sure that the installation of this BMP does not violate State ground water regulations.

If it is possible that the collection basin may handle combustible or flammable spilled materials, explosion-proof pumping equipment and controls or other appropriate precautions should be taken to prevent explosions or fires. Consult OSHA and local safety codes and standards for specific requirements and guidance.

Advantages of Collection Basins
• Can store contaminated storm water until directed to a treatment facility • Can collect spills for recycling where materials are separated
Disadvantages of Collection Basins
• May need a conveyance system for increased effectiveness • May collect materials that are not compatible • May reduce the potential for recycling materials by collecting storm water, which dilutes the materials • May create ground water problems if pollutants infiltrate into ground

Sumps

What Are They

Sumps are holes or low areas that are structured so that liquid spills or leaks will flow down toward a particular part of a containment area. Frequently, pumps are placed in a depressed area and are turned on automatically to transfer liquids away from the sump when the level of liquids gets too high. Sumps can be temporary or permanent.

When and Where to Use Them

Sumps can be used at all facilities. Sumps are used with other spill containment and treatment measures and can be located almost anywhere onsite. Sumps are frequently located in low lying areas within material handling or storage areas.

What to Consider

When designing and installing a sump system, consider the pump location, function, and system alarms. Design and install the sump in the lowest lying area of a containment structure, allowing for materials to gather in the area of the sump. Construct the sump of impenetrable materials and provide a smooth surface so that liquids are funneled toward the pump. It may be appropriate to house the pumps in a shed or other structure for protection and stabilization.

There are numerous factors that should be considered when purchasing a pump. Base the size of the pump on the maximum expected volume to be collected in the containment structure. In some cases, more than one pump may be appropriate. Typically, pumps that can be submerged under the spill are the most appropriate for areas where large spills may occur and that may submerge the sump area. The viscosity (thickness) of the material and the distance that the material must be pumped are also important considerations. Install pumps according to the manufacturer's recommendations.

An alarm system can be installed for pumps that are used to remove collected materials. An alarm system can indicate that a pump should be operated by hand or that an automatically operated pump has failed to function. Ultimately, facility personnel should have some mechanism to take action to prevent spills from by-passing and overflowing containment structures.

The pumps and the alarm system used in the sump generally require regular inspections for service and maintenance of parts based on manufacturers' recommendations.

If it is possible that the sump may handle combustible or flammable spilled materials, explosion-proof pumping equipment and controls or other appropriate precautions should be taken to prevent explosions or fires. Consult OSHA and local safety codes and standards for specific requirements and guidance.

Advantages of Sumps
• Provide a simple and quick collection method for recycling, reusing, or treating materials in a containment structure • Are commonly used at industrial facilities
Disadvantages of Sumps
• Pumps may clog easily if not designed correctly • May require maintenance/servicing agreements with pump dealers • Costs for purchasing and/or replacing pumps may be high

Covering

What Is It

Covering is the partial or total physical enclosure of materials, equipment, process operations, or activities. Covering certain areas or activities prevents storm water from coming into contact with potential pollutants and reduces material loss from wind blowing. Tarpaulins, plastic sheeting, roofs, buildings, and other enclosures are examples of covering that are effective in preventing storm water contamination. Covering can be temporary or permanent.

When and Where to Use It

Covering is appropriate for outdoor material storage piles (e.g., stockpiles of dry materials, gravel, sand, compost, sawdust, wood chips, de-icing salt, and building materials) and areas where liquids and solids in containers are stored or transferred. Although it may be too expensive to cover or enclose all industrial activities, cover high-risk areas (identified during the storm water pollutant source identification). For example, cover chemical preparation areas, vehicle maintenance areas, areas where chemically treated products are stored, and areas where salts are stored.

If covering or enclosing the entire activity is not possible, the high-risk part of the activity can often be separated from other processes and covered. Another option that reduces the cost of building a complete enclosure is to build a roof over the activity. A roof may also eliminate the need for ventilation and lighting systems (Washington State, 1992).

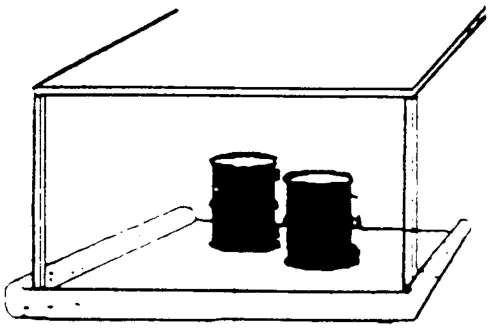
What to Consider

Evaluate the strength and longevity of the covering, as well as its compatibility with the material or activity being enclosed. When designing an enclosure, consider access to materials, their handling, and transfer. Materials that pose environmental and safety dangers because they are radioactive, biological, flammable, explosive, or reactive require special ventilation and temperature considerations.

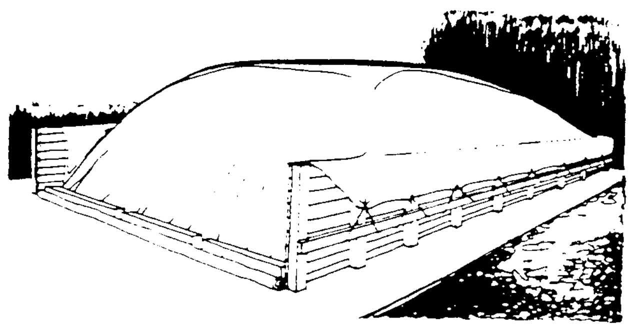
Covering alone may not protect exposed materials from storm water contact. Place the material on an elevated, impermeable surface or build curbing around the outside of the materials to prevent problems from runon of uncontaminated storm water from adjacent areas.

Frequently inspect covering, such as tarpaulins, for rips, holes, and general wear. Anchor the covering with stakes, tie-down ropes, large rocks, tires, or other easily available heavy objects.

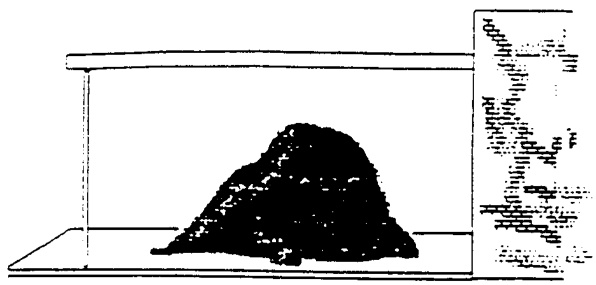
Practicing proper materials management within an enclosure or underneath a covered area is essential. For example, floor drainage within an enclosure should be properly designed and connected to the wastewater sewer where appropriate and allowed. If connection to an offsite wastewater sewer is considered, the local Publicly Owned Treatment Works (POTW) should be consulted to find out if there are any pretreatment requirements or restrictions that must be followed.



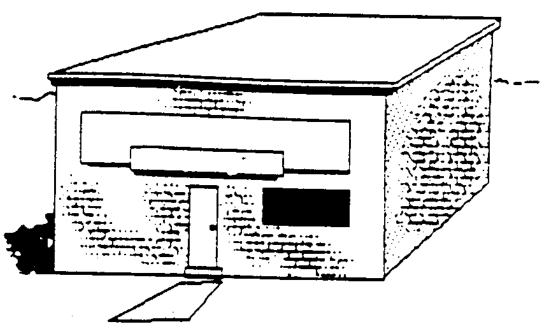
Small Chemical Storage Area
with Curbing and Cover



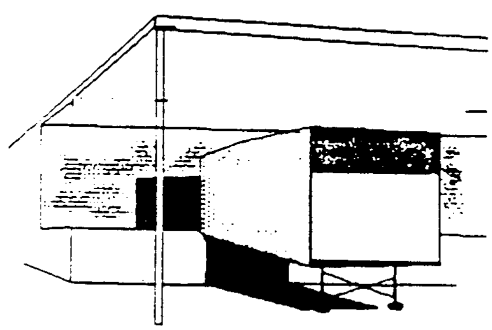
Raw Material Storage Covered with Tarpaulin



Covered Area for Raw Materials



Enclosed Area for Storage of
Raw Materials or Chemicals



Covered Area for Loading and Unloading

FIGURE 4.7 EXAMPLE COVERING FOR INDUSTRIAL ACTIVITIES
(Modified from Washington State, 1992; Salt Institute, 1987)

Advantages of Covering
• Is simple and effective • Is commonly inexpensive
Disadvantages of Covering
• Requires frequent inspection • May pose health or safety problems if enclosure is built over certain activities

Vehicle Positioning

What Is It

Vehicle positioning is the practice of locating trucks or rail cars while transferring materials to prevent spills of materials onto the ground surface, which may then contaminate storm water runoff. Vehicle positioning is a simple and effective method of material spill prevention and yet it is commonly overlooked.

When and Where to Use It

Vehicle positioning can be used at all types of industrial facilities. This practice is appropriate for any area where materials are transferred from or to vehicles, such as loading and unloading areas, storage areas, and material transfer areas. Use vehicle positioning in conjunction with other practices such as covering, sumps, drip pans, or loading and unloading by air pressure or vacuum where chemical spills are of concern.

What to Consider

The purpose of vehicle positioning is to locate vehicles in a stable and appropriate position to prevent problems, such as spills resulting from broken material storage containers, spills caused by vehicle movement during materials transfer activities, and spills caused by improperly located vehicles. Vehicles should also be positioned near containment or flow diversion systems to collect unexpected spills from leaks in transfer lines or connections. The following activities are included in this practice:

- Constructing walls that help in positioning the vehicles
- Positioning vehicle either over a drain or on a sloped surface that drains to a containment structure
- Outlining required vehicle positions on the pavement
- Using wheel guards or wheel blocks
- Posting signs requiring the use of emergency brakes
- Requiring vehicles to shut off engines during materials transfer activities.

Advantages of Vehicle Positioning
• Is inexpensive • Is easy and effective
Disadvantages of Vehicle Positioning
• May require redesign of loading and unloading areas

Loading and Unloading by Air Pressure or Vacuum

What Is It

Air pressure and vacuum systems are commonly used for transporting and loading and unloading materials. These systems are simple to use and effective in transferring dry chemicals or solids from one area to another, but are less effective as the particles of material become more dense.

In an air pressure system, a safety-relief valve and a dust collector are used to separate the dry materials from the air and then release the air accumulated during transfer operations. In a vacuum system, a dust collection device and an air lock, such as a rotary gate or trap door feeder, are typically used.

The use of mechanical equipment that involves enclosed lines, such as those provided by air pressure (also referred to as pneumatic) and vacuum loading systems, are effective methods for minimizing releases of pollutants into the environment. Because of the enclosed nature of the system, pollutants are not exposed to wind or precipitation and therefore have less potential to contaminate storm water discharges.

When and Where to Use It

Air pressure and vacuum systems can be used at all types of industrial facilities. This equipment is located in material handling areas to use for storing, loading and unloading, transporting, or conveying materials.

What to Consider

Unlike many of the other BMPs discussed in this manual, air pressure and vacuum systems may be expensive because of the costs of purchasing the system and retrofitting the system to existing materials handling procedures. In many cases, these systems can be shipped to a facility and be installed onsite without contractor help. Manufacturer's recommendations should be followed closely to ensure proper installation. In other cases, systems may have to be designed specifically for a site. Proper design and installation are very important for air pressure and vacuum systems to be as effective as possible. The equipment may be weatherproof or, if not, consider enclosing or covering the equipment.

Conduct routine inspections of air pressure and vacuum systems. Regular maintenance is required of these systems, especially the dust collectors. Conduct maintenance activities based on manufacturers' recommendations. Inspect air pressure systems more frequently due to the greater potential for leaks to the environment.

Advantages of Loading and Unloading by Air Pressure or Vacuum
• Is quick and simple • May be economical if materials can be recovered • Will minimize exposure of pollutants to storm water
Disadvantages of Loading and Unloading by Air Pressure or Vacuum
• May be costly to install and maintain • May not be appropriate for some denser materials • May require site-specific design • Dust collectors may need a permit under the Clean Air Act to install

4.3 MITIGATIVE PRACTICES

Mitigation involves cleaning up or recovering a substance after it has been released or spilled to reduce the potential impact of a spill before it reaches the environment. Therefore, pollution mitigation is a second line of defense where pollution prevention practices have failed or are impractical. Because spills cannot always be avoided at industrial sites, it is necessary to plan for these events and to design proper response procedures. This section discusses mitigative BMPs to avoid contamination of storm water. Most of the mitigative practices discussed are simple and should be incorporated in your facility's good housekeeping and spill response plans. The mitigation practices discussed include manual cleanup methods, such as sweeping and shoveling, mechanical cleanup by excavation or vacuuming, and cleanup with sorbents and gels.

Facilities are cautioned that spills of certain toxic and hazardous substances and their cleanup may be covered under regulations, including those imposed under the Superfund Amendments and Reauthorization Act (SARA), the Comprehensive Environmental Responsibility, Compensation, and Liability Act (CERCLA), and the Resource Conservation and Recovery Act (RCRA).

Sweeping

What Is It

Sweeping with brooms, squeegees, or other mechanical devices is used to remove small quantities of dry chemicals and dry solids from areas that are exposed to precipitation or storm water runoff. These areas may include dust or contaminant covered bags, drums containing remaining materials on their lids, areas housing enclosed or covered materials, and spills of dry chemicals and dry solids in locations on the industrial site. Cleaning by sweeping with brooms is a low cost practice that can be performed by all employees and requires no special equipment or training.

When and Where to Use It

Sweeping can be used at many material handling areas and process areas in all types of industrial facilities. Timing is an important consideration for all mitigative practices. To be effective as a storm water control, cleanup must take place before rainfall or contact with storm water runoff or before an outside area is hosed down.

Do not limit your cleanup activities to those outside activities that are exposed to rainfall. In many cases, tracking of materials to the outside from areas that are enclosed or covered (e.g., on shoes) may also occur.

What to Consider

Store brooms appropriately and do not expose them to precipitation. In addition, rules of compatibility also apply. Do not use the same broom to clean up two chemicals that are incompatible. Determine the compatibility between the brooms themselves and the chemical of concern before using this practice. In some instances, chemicals should be vacuumed instead of swept. Be sure that swept material is disposed of properly.

Advantages of Sweeping
• Is inexpensive • Requires no special training • Provides recycling opportunities
Disadvantages of Sweeping
• Is a labor-intensive practice • Is limited to small releases of dry materials

Shoveling

What Is It

Shoveling is another manual cleanup method that is simple and low in cost. Generally, shoveling can be used to remove larger quantities of dry chemicals and dry solids, as well as to remove wetter solids and sludge. Shoveling is also useful in removing accumulated materials from sites not accessible by mechanical cleanup methods.

When and Where to Use It

Shoveling can be used at any facility. Shoveling provides an added advantage over sweeping because cleanup methods are not limited to dry materials. In many cases, accumulated solids and sludges that are in ditches, sumps, or other facility locations can be effectively and quickly removed by shoveling.

Shovels can also be used to clean up contaminated snows. Timing is an important consideration in any mitigative practice. Materials that could contaminate storm water runoff should be removed before any storm event.

What to Consider

As with brooms, clean and store shovels properly. Also, consider planning for the transport and disposal or reuse of the shoveled materials.

Advantages of Shoveling
• Is inexpensive • Provides recycling opportunities • Can remediate larger releases and is effective for dry and wet materials
Disadvantages of Shoveling
• Is labor-intensive • Is not an appropriate practice for large spills

Excavation Practices

What Are They

Excavation (i.e., removal of contaminated material) of released materials is typically conducted by mechanical equipment, such as plows and backhoes. Generally, plowing and backhoeing can be done using a specifically designed vehicle, tractor, or truck.

Excavation removes the materials of concern and any deposition of contaminants, thereby reducing the potential for storm water contamination. Mechanical cleanup methods are typically less precise than manual cleanup methods, resulting in reduced opportunities for recycle and reuse.

When and Where to Use Them

Excavation practices are most useful for large releases of dry materials and for areas contaminated by liquid material releases. In excavation, you want to be sure that all of the contaminated material is removed.

Timing is an important consideration for all mitigative practices. To be effective as a storm water control, cleanup must take place before a rainfall event.

What to Consider

Conduct inspections and operations and maintenance in accordance with a manufacturer's recommendations, which may include the following:

- A specified frequency for inspection, maintenance, and servicing of the equipment
- Parts replacement, rotation, and lubrication specifications
- Procedures for evaluating all parts.

As with any equipment used during cleanup, other considerations apply, including the following:

- Plows, backhoes, etc. should be stored appropriately with no exposure to precipitation
- Excavated materials should be properly handled or disposed of.

Advantages of Excavation Practices
• Are a cost effective method for cleaning up dry materials release • Are common and simple
Disadvantages of Excavation Practices
• Are less precise, resulting in less recycling and reuse opportunities

Vacuum and Pump Systems

What Are They

Vacuum and pump systems are effective for cleaning up spilled or exposed materials.

The benefits of vacuum and pump cleanup systems include simplicity and speed. With such systems, only the spilled materials need be collected. Also, these systems are often portable and can be used at many locations to clean up releases to the environment. Portable systems can usually be rented.

When and Where to Use Them

Vacuum and pump systems can be used at any industrial facility. Both wet and dry materials can be collected with these systems. Vacuum systems can be used in material handling areas and process areas.

What to Consider

Consider the area of use and the most appropriate size for the system. Since these systems can be portable, size is important, especially if materials will be stored in the unit. In this case, the portable system must have enough suction or positive air pressure to transport materials over long distances. Include plans for proper disposal or reuse of the collected materials.

Advantages of Vacuum and Pump Systems
• Remove materials by air pressure or vacuum quickly and simply • Collect materials accurately • Offer good recycling opportunities
Disadvantages of Vacuum and Pump Systems
• May require high initial capital cost • Require equipment maintenance

Sorbents

What Are They

Sorbents are materials that are capable of cleaning up spills through the chemical processes of adsorption and absorption. Sorbents adsorb (an attraction to the outer surface of a material) or absorb (taken in by the material like a sponge) only when they come in contact with the sorbent materials. The sorbents must be mixed with a spill or the liquid must be passed through the sorbent. Sorbent materials come in many different forms from particles to foams. Often the particles are held together in structures called booms, pads, or socks. Sorbents include, but are not limited to, the following:

- **Common Materials (clays, sawdust, straw, and flyash)**—Generally come in small particles that can be thrown onto a spill that is on a surface. The materials absorb the spill by taking up the liquid.
- **Polymers (polyurethane and polyolefin)**—Come in the form of spheres, beads, or foam tablets. These materials absorb a chemical spill by taking up the liquid into their open-pore structure.
- **Activated Carbon**—Comes in a powdered or granular form and can be mixed with liquids to remove pollutants. This sorbent works by adsorbing the organics to its surface and can be recycled and then reused by a process called regeneration.
- **"Universal Sorbent Material"**—Is a silicate glass foam consisting of rounded particles that can absorb the material.

When and Where to Use Them

Sorbents are useful BMPs for facilities with liquid materials onsite. Timing is important for these practices. To be effective as a storm water BMP, cleanup must take place before a rainfall. Sorbents are often used in conjunction with curbing to provide cleanup of small spills within a containment area.

"Universal Sorbent Materials" are suitable for use on many compounds including acids, alkalis, alcohols, aldehydes, arsenate, ketones, petroleum products, and chlorinated solvents.

Activated carbon is useful for adsorbing many organic compounds. Organics that are diluted in water can be passed through a column that is filled with the activated carbon material to remove the organics, or the activated carbon can be mixed into the water and can then be filtered out.

Polyurethane is good with chemical liquids such as benzene, chlorinated solvents, epicholorhydrin, and phenol. Polyolefin is used to remove organic solvents, such as phenol and various chlorinated solvents. The beads and spheres are usually mixed into a spill by use of a blower and then are skimmed from the top surface by use of an oil boom.

More common materials such as clay, sawdust, straw, and fly-ash can be used for a liquid spill on a surface that is relatively impenetrable, and are usually spread over the spill area with shovels.

Booms, pads, and socks are also useful in areas where there are small liquid spills or drips or where small amounts of solids may mix with small amounts of storm water runoff. They can function both to absorb the pollutants from the storm water and restrict the movement of a spill. Socks are often used together with curbing to clean up small spills.

What to Consider

Because sorbents work by a chemical or physical reaction, some sorbents are better than others for certain types of spills. Therefore, the use of sorbents requires that personnel know the properties of the spilled material(s) to know which sorbent is appropriate. To be effective, sorbents must adsorb the material spilled but must not react with the spilled material to form hazardous or toxic substances. Follow the manufacturers' recommendations.

For sorbents to be effective, they must be applied immediately in the release area. The use of sorbent material is generally very simple: the sorbent is added to the area of release, mixed well, and allowed to adsorb or absorb. Many sorbents are not reusable once they have been used. Proper disposal is required.

Advantages of Sorbents
• Work in water environments (booms and socks) • Offer recycling opportunities (some types of sorbents)
Disadvantages of Sorbents
• Require a knowledge of the chemical makeup of a spill (to choose the best sorbent) • Offer no recycling opportunities (some types of sorbents) • May be expensive practice for large spills • May create disposal problems and increase disposal costs by creating a solid waste and potentially a hazardous waste.

Gelling Agents

What Are They

Gelling agents are materials that interact with liquids either physically or chemically (i.e., thickening or polymerization). Some of the typical gelling agents are polyelectrolytes, polyacrylamide, butylstyrene copolymers, polyacrylonitrile, polyethylene oxide, and a gelling agent referred to as the universal gelling agent which is a combination of these synthetics.

Gelling interacts with a material by concentrating and congealing it to become semisolid. The semisolid gel later forms a solid material, which can then be cleaned up by manual or mechanical methods. The BMP of using a gelling agent is one of the few ways to effectively control a liquid spill before it reaches a receiving water or infiltrates into the soil and then ground water.

When and Where to Use Them

Gelling agents are useful for facilities with significant amounts of liquid materials stored onsite. Gels cannot be used to clean up spills on surface water unless authorized by the U.S. Coast Guard or EPA Regional Response Team.

What to Consider

Gels can be used to stop the liquid's flow on land, prevent its seeping into the soil, and reduce the surface spreading of a spill. Because of these properties, gels can reduce the need for extensive cleanup methods and reduce the possibility of storm water contamination from an uncontrolled industrial spill. As with sorbents, the use of gels simply involves the addition of the gel to the area of the spill, mixing well, and allowing the mass to congeal. To use gels correctly, however, personnel need to know the properties of the spilled materials so that they can choose the correct gel.

Timing is particularly important for gelling agent use. To prevent the movement of materials, gelling agents must be applied immediately after the spill. The use of gelling agents results in a large bulk of congealed mass that usually cannot be separated. Ultimately, this mass will need to be cleaned up by manual or mechanical methods and disposed of properly.

Advantages of Gelling Agents
• Stop the movement of spilled or released liquid materials • Require no permanent structure
Disadvantages of Gelling Agents
• May require knowledge of the spilled materials to select correct gelling agents • Usually offer no recycling opportunities • May be difficult to clean up • May create disposal problems and increase disposal costs by creating a solid waste and potentially a hazardous waste

4.4 OTHER PREVENTIVE PRACTICES

A number of preventive measures can be taken at industrial sites to limit or prevent the exposure of storm water runoff to contaminants. This section describes a few of the most easily implemented measures:

- Preventive Monitoring Practices
- Dust Control (Land Disturbance and Demolition Areas)
- Dust Control (Industrial)
- Signs and Labels
- Security
- Area Control Procedures
- Vehicle Washing.

Preventive Monitoring Practices

What Are They

Preventive monitoring practices include the routine observation of a process or piece of equipment to ensure its safe performance. It may also include the chemical analysis of storm water before discharge to the environment.

When and Where to Use Them

Automatic Monitoring System—In areas where overflows, spills, and catastrophic leaks are possible, an automatic monitoring system is recommended. Some Federal, State, and local laws require such systems to be present if threats exist to the health and safety of personnel and the environment. For material management areas, monitoring may include liquid level detectors, pressure and temperature gauges, and pressure-relief devices. In material transfer, process, and material handling areas, automatic monitoring systems can include pressure drop shutoff devices, flow meters, thermal probes, valve position indicators, and operation lights. Loading and unloading operations might use these devices for measuring the volume of tanks before loading, for weighing vehicles or containers, and for determining rates of flow during loading and unloading.

Automatic Chemical Monitoring—Measures the quality of plant runoff to determine whether discharge is appropriate or whether diversion to a treatment system is warranted. Such systems might monitor pH, turbidity, or conductivity. These parameters might be monitored in diked areas, sewers, drainage ditches, or holding ponds. Systems can also be designed to signal automatic diversion of contaminated storm water runoff to a holding pond (e.g., a valve or a gate could be triggered by a certain pollutant in the storm water runoff).

Manned Operations—In material transfer areas and process areas, personnel can be stationed to watch over the operations so that any spills or mismanagement of materials can be corrected immediately. This is particularly useful at loading and unloading areas where vehicles or equipment must be maneuvered into the proper position to unload (see Vehicle Positioning BMP).

Nondestructive Testing—Some situations require that a storage tank or a pipeline system be tested without being physically moved or disassembled. The structural integrity of tanks, valves, pipes, joints, welds, and other equipment can be tested using nondestructive methods. Acoustic emission tests use high frequency sound waves to draw a picture of the structure to reveal cracks, malformations, or other structural damage. Another type of testing is hydrostatic pressure testing. During pressure testing, the tank or pipe is subjected to pressures several times the normal pressure. A loss in pressure during the testing may indicate a leak or some other structural damage. Tanks and containers should be pressure tested as required by Federal, State, or local regulations.

What to Consider

Automated monitoring systems should be placed in an area where plant personnel can easily observe the measurements. Alarms can be used in conjunction with the measurement display to warn personnel. Manned operations should have communication systems available for getting help in case spills or leaks occur. Especially sensitive or spill-prone areas may require back-up instrumentation in case the primary instruments malfunction.

Mechanical and electronic equipment should be operated and maintained according to the manufacturers' recommendations. Equipment should be inspected regularly to ensure proper and accurate operation.

The pollution prevention team, in consultation with a certified safety inspector, should evaluate system monitoring requirements to decide which systems are appropriate based on hazard potential.

Advantages of Preventive Monitoring Practices
• Pressure and vacuum testing can locate potential leaks or damage to vessels early. The primary benefit of such testing is in ensuring the safety of personnel, but it also has secondary benefits including prevention of storm water contamination. • Automatic system monitors allow for early warnings if a leak, overflow, or catastrophic incident is imminent. • Manning operations, especially during loading and unloading activities, is effective and generally inexpensive. • The primary benefit of nondestructive testing is in ensuring the safety of personnel, but it also has secondary benefits including early detection of the potential for contaminating storm water runoff.
Disadvantages of Preventive Monitoring Practices
• Plant personnel often do not have the expertise to maintain automatic equipment. • Automatic equipment can fail without warning. • Automated process control and monitoring equipment may be expensive to purchase and operate

Dust Control (Land Disturbance and Demolition Areas)

What Is It

Dust controls for land disturbance and demolition areas are any controls that reduce the potential for particles being carried through air or water. Types of dust control are:

- **Irrigation**—Irrigation is a temporary measure involving a light application of water to moisten the soil surface. The process should be repeated as necessary.

- **Minimization of Denuded Areas**—Minimizing soil exposure reduces the amount of soil available for transport and erosion. Soil exposure can be lessened by temporary or permanent soil stabilization controls, such as seeding, mulching, topsoiling, crushed stone or coarse gravel spreading, or tree planting. Maintaining existing vegetation on a site will also help control dust.

- **Wind Breaks**—Wind breaks are temporary or permanent barriers that reduce airborne particles by slowing wind velocities (slower winds do not suspend particles). Leaving existing trees and large shrubs in place will create effective wind breaks. More temporary types of wind breaks are solid board fences, snow fences, tarp curtains, bales of hay, crate walls, and sediment walls.
- **Tillage**—Deep plowing will roughen the soil surface to bring up to the surface cohesive clods of soil, which in turn rest on top of dusts, protecting them from wind and water erosion. This practice is commonly practiced in arid regions where establishing vegetation may take time.

- **Chemical Soil Treatments (palliatives)**—These are temporary controls that are applied to soil surfaces in the form of spray-on adhesives, such as anionic asphalt emulsion, latex emulsion, resin-water emulsions, or calcium chloride. The palliative is the chemical used. These should be used with caution as they may create pollution if not used correctly.

When and Where to Use It

Dust controls can be used on any site where dust may be generated and where the dust may cause onsite and offsite damage. Dust controls are especially critical in arid areas, where reduced rainfall levels expose soil particles for transport by air and runoff. This control should be used in conjunction with other sedimentation controls such as sediment traps.

What to Consider

To control dust during land disturbance and at demolition areas, exposure of soil should be limited as much as possible. When possible, work that causes soil disturbance or involves demolition should be done in phases and should be accompanied by temporary stabilization measures. These precautions will minimize the amount of soil that is disturbed at any one time and, therefore, control dust.

Oil should not be used to control dust because of its high potential for polluting storm water discharges.

Irrigation will be most effective if site drainage systems are checked to ensure that the right amount of water is used. Too much water can cause runoff problems.

Chemical treatment is only effective on mineral soils, as opposed to muck soils, because the chemicals bond better to mineral soils. Therefore, it should be used only in arid regions. Vehicular traffic should be routed around chemically treated areas to avoid tracking of the chemicals. Certain chemicals may be inappropriate for some types of soils or application areas. For example, spraying chemicals on the soil of an industrial site adjacent to a school may be dangerous. Local governments usually have information about restrictions on the types of palliatives that may be used. Special consideration must be given to preserving ground water quality whenever chemicals are applied to the land.

Since most of these techniques are temporary controls, sites should be inspected often and materials should be reapplied when needed. The frequency for these inspections depends on site-specific conditions, weather conditions, and the type of technique used.

Advantages of Dust Control (Land Disturbance and Demolition Areas)
• Can help prevent wind-and-water based erosion of disturbed areas and will reduce respiratory problems in employees • Some types can be implemented quickly at low cost and effort (except wind breaks) • Helps preserve the aesthetics of the site and screens certain activities from view (wind breaks) • Vegetative wind breaks are permanent and an excellent alternative to chemical use

Disadvantages of Dust Control (Land Disturbance and Demolition Areas)
• Some types are temporary and must be reapplied or replenished regularly • Some types are expensive (irrigation and chemical treatment) and may be ineffective under certain conditions • May result in health and/or environmental hazards, e.g., if overapplication of the chemicals leaves large amounts exposed to wind and rain erosion or ground water contamination • May create excess runoff that the site was not designed to control (irrigation) • May cause increased offsite tracking of mud (irrigation) • Is not as effective as chemical treatment or mulching and seeding; requires land space that may not be available at all locations (wind breaks)

Dust Control (Industrial)

What Is It

Dust controls for material handling areas are controls that prevent pollutants from entering storm water discharges by reducing the surface and air transport of dust caused by industrial activities. Consider the following types of controls:

- Water spraying
- Negative pressure systems (vacuum systems)
- Collector systems (bag and cyclone)
- Filter systems
- Street sweeping.

The purpose of industrial dust control is to collect or contain dusts to prevent storm water runoff from carrying the dusts to the sewer collection system or to surface waters.

When and Where to Use It

Dust control is useful in any process area, loading and unloading area, material handling areas, and transfer areas where dust is generated. Street sweeping is limited to areas that are paved.

What to Consider

Mechanical dust collection systems are designed according to the size of dust particles and the amount of air to be processed. Manufacturers' recommendations should be followed for installation (as well as the design of the equipment).

If water sprayers are used, dust-contaminated waters should be collected and taken for treatment. Areas will probably need to be resprayed to keep dust from spreading.

Two kinds of street sweepers are common: brush and vacuum. Vacuum sweepers are more efficient and work best when the area is dry.

Mechanical equipment should be operated according to the manufacturers' recommendations and should be inspected regularly.

Advantages of Dust Control (Industrial)
• May cause a decrease of respiratory problems in employees around the site • May cause less material to be lost and may therefore save money • Provides efficient collection of larger dust particles (street sweepers)
Disadvantages of Dust Control (Industrial)
• Is generally more expensive than manual systems • May be impossible to maintain by plant personnel (the more elaborate equipment) • Is labor and equipment intensive and may not be effective for all pollutants (street sweepers)

Signs and Labels

What Are They

Signs and labels identify problem areas or hazardous materials at a facility. Warning signs, often found at industrial facilities, are a good way to suggest caution in certain areas. Signs and labels can also provide instructions on the use of materials and equipment. Labelling is a good way to organize large amounts of materials, pipes, and equipment, particularly on large sites.

Labels tell material type and container contents. Accurate labeling can help facilities to quickly identify the type of material released so facility personnel can respond correctly.

Two effective labeling methods include color coding and Department of Transportation (DOT) labeling. Color coding is easily recognized by facility personnel and simply involves painting/coating or applying an adhesive label to the container. Color codes must be consistent throughout the facility to be effective, and signs explaining the color codes should be posted in all areas.

DOT requires that labels be prominently displayed on transported hazardous and toxic materials. Labeling required by DOT could be expanded to piping and containers, making it easy to recognize materials that are corrosive, radioactive, reactive, flammable, explosive, or poisonous.

FIGURE 4.8 SIGN ON DRUM INDICATING FLAMMABILITY

When and Where to Use Them

Signs and labels can be used at all types of facilities. Areas where they are particularly useful are material transfer areas, equipment areas, loading and unloading areas, or anywhere information might prevent contaminants from being released to storm water.

What to Consider

Signs and labels should be visible and easy to read. Useful signs and labels might provide the following information:

- Names of facility and regulatory personnel, including emergency phone numbers, to contact in case of an accidental discharge, spill, or other emergency
- Proper uses of equipment that could cause release of storm water contaminants
- Types of chemicals used in high-risk areas
- The direction of drainage lines/ditches and their destination (treatment or discharge)
- Information on a specific material
- Refer to OSHA standards for sizes and numbers of signs required for hazardous material labeling.

Hazardous chemicals might be labeled as follows:

- Danger
- Combustible
- Warning
- Caution
- Flammable
- Poisonous
- Caustic
- Corrosive
- Volatile
- Explosive

Periodic checks can ensure that signs are still in place and labels are properly attached. Signs and labels should be replaced and repaired as often as necessary.

Advantages of Signs and Labels
• Are inexpensive and easily used
Disadvantages of Signs and Labels
• Must be updated and maintained so they are legible

Security

What Is It

Setting up a security system as part of your Plan could help prevent an accidental or intentional release of materials to storm water runoff as a result of vandalism, theft, sabotage, or other improper uses of facility property. If your facility already has a security system, consider improving it by training security personnel about the specifics of the Storm Water Pollution Prevention Plan. Routine patrol, lighting, and access control are discussed below as possible measures to include in your facility's security system.

When and Where to Use It

Routine patrol, lighting, and access control are measures that can be used at any facility.

What to Consider

Security information could be included in the existing training required by the Plan to instruct personnel about where and how to patrol areas within the facility. Instruction might also include what to look for in problem areas and how to respond to problems. During routine patrol, security personnel can actively search the facility site for indications of spills, leaks, or other discharges; respond to any disturbance resulting from intruders or inappropriate facility operations; and generally work as a safeguard to prevent unexpected events. Routine patrols could be an effective part of the Storm Water Pollution Prevention Plan, especially for large facilities with established security measures. To make this practice effective, security personnel can help develop the Storm Water Pollution Prevention Plan, possibly with one person acting as a member of the pollution prevention committee.

Sufficient lighting throughout the facility during daytime and night hours will make it easier to get to equipment during checks and will make it easy to detect spills and leaks that might otherwise be hidden. Routine patrols are also easier with proper lighting.

Controlling access to the industrial site is an important part of plant security and of activity and traffic control. Signs, fencing, guard houses, dog patrols, and visitor clearance requirements are often used to control site access.

- Signs are the simplest, most inexpensive method of access control, but they are limited in their actual control since they provide no physical barriers and require that people obey them voluntarily.

- Fencing provides a physical barrier to the facility site and an added means of security.

- Guard houses used with visitor rules can help to ensure that only authorized personnel enter the facility site and can limit vehicular traffic as well.

- Traffic signs are also useful at facility sites. Restricting vehicles to paved roads and providing direction and warning signs can help prevent accidents. Where restricting vehicles to certain pathways is not possible, it is important to ensure that all above-ground valves and pipelines are well marked.

Advantages of Security
• Provides a preventive safeguard to operational malfunctions or other facility disturbances (routine patrols) • Allows easier detection of vandals or thieves (lighting) • Allows easier detection of spills, leaks, or other releases (lighting) • Prevents spills by providing good visibility (lighting) • Prevents unauthorized access to facility (access control)
Disadvantages of Security
• May not be feasible for smaller facilities • May be costly (e.g., installation of lighting systems) • May increase energy costs as a result of additional lighting • May not be feasible to have extensive access controls at smaller facilities

Area Control Procedures

What Are They

The activities conducted at an industrial site often result in the materials being deposited on clothes and footwear and the being carried throughout the facility site. As a result, these materials may find their way into the storm water runoff.

Area control procedures involve practicing good housekeeping measures such as maintaining indoor or covered material storage and industrial processing areas. If the area is kept clean, the risk of accumulating materials on footwear and clothing is reduced. In turn, the chance of left over pollutants making contact with storm water and polluting surface water is minimized.

When and Where to Use Them

Area control measures can be used at any facility where materials may be tracked into areas where they can come in contact with storm water runoff. Areas can include material handling areas, storage areas, or process areas.

What to Consider

Materials storage areas and industrial processing areas should be checked regularly to ensure that good housekeeping measures are being implemented. Cover-garments, foot mats, and other devices used to collect residual material near the area should be cleaned regularly.

Other effective practices include the following:

- Brushing off clothing before leaving the area
- Stomping feet to remove material before leaving the area
- Using floor mats at area exits
- Using coveralls, smocks, and other overgarments in areas where exposure to material is of greatest concern (employees should remove the overgarments before leaving the area)
- Posting signs to remind employees about these practices.

Advantages of Area Control Procedures
• Are easy to implement • Result in a cleaner facility and improved work environment
Disadvantage of Area Control Procedures
• May be seen as tedious by employees and therefore may not be followed

Vehicle Washing

What Is It

Materials that accumulate on vehicles and then scatter across industrial sites represent an important source of storm water contamination. Vehicle washing removes materials such as site-specific dust and spilled materials that have accumulated on the vehicle. If not removed, residual material will be spread by gravity, wind, snow, or rainfall as the vehicles move across the facility site and off the site.

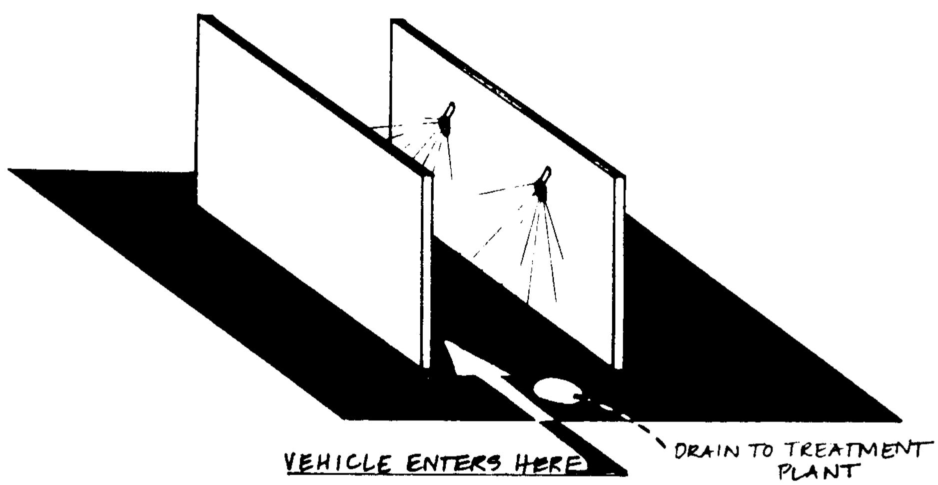


FIGURE 4.9 TRUCK WASHING AREA

When and Where to Use It

This practice is appropriate for any facility where vehicles come into contact with raw materials on a site. If possible, the vehicle washing area should be built near the location where the most vehicle activity occurs. Wastewater from vehicle washing should be directed away from process materials to prevent contact. Those areas include material transfer areas, loading and unloading areas, or areas located just before the site exit.

What to Consider

When considering the method of vehicle washing, the facility should consider using a high-pressure water spray with no detergent additives. In general, water will adequately remove contaminants from the vehicle. If detergents are used, they may cause other environmental impacts. Phosphate- or organic-containing compounds should be avoided.

If this practice is considered, truck wash waters will result in a non-storm water discharge, thus requiring an application for an NPDES permit to cover the discharge.

Blowers or vacuums should be considered where the materials are dry and easily removed by air.

Advantages of Vehicle Washing
• Prevents dispersion of materials across the facility site • Is necessary only where methods for transferring contained materials and minimizing exposure have not been successfully adopted and implemented
Disadvantages of Vehicle Washing
• May be costly to construct a truck washing facility

4.5 SEDIMENT AND EROSION PREVENTION PRACTICES

Any site where soils are exposed to water, wind or ice can have soil erosion and sedimentation problems. Erosion is a natural process in which soil and rock material is loosened and removed. Sedimentation occurs when soil particles are suspended in surface runoff or wind and are deposited in streams and other water bodies.

Human activities can accelerate erosion by removing vegetation, compacting or disturbing the soil, changing natural drainage patterns, and by covering the ground with impermeable surfaces (pavement, concrete, buildings). When the land surface is developed or "hardened" in this manner, storm water and snowmelt can not seep into or "infiltrate" the ground. This results in larger amounts of water moving more quickly across a site which can carry more sediment and other pollutants to streams and rivers.

EPA's General Permit requires that all industries identify in their Storm Water Pollution Prevention Plans areas that may have a high potential for soil erosion. This includes areas with such heavy activity that plants cannot grow, soil stockpiles, stream banks, steep slopes, construction areas, demolition areas, and any area where the soil is disturbed, denuded (stripped of plants), and subject to wind and water erosion. EPA further requires that you take steps to limit this erosion.

There are seven ways to limit and control sediment and erosion on your site:

- Leave as much vegetation (plants) onsite as possible.
- Minimize the time that soil is exposed.
- Prevent runoff from flowing across disturbed areas (divert the flow to vegetated areas).
- Stabilizing the disturbed soils as soon as possible.
- Slow down the runoff flowing across the site.
- Provide drainage ways for the increased runoff (use grassy swales rather than concrete drains).
- Remove sediment from storm water runoff before it leaves the site.

Using these measures to control erosion and sedimentation is an important part of storm water management. Selecting the best set of sediment and erosion prevention measures for your industry depends upon the nature of the activities on your site (i.e., how much construction or land disturbance there is) and other site-specific conditions (soil type, topography, climate, and season). Section 4.5.1 discusses some temporary and permanent ways to stabilize your site. Section 4.5.2 describes more structural ways to control sediment and erosion.

In some arid regions, growing vegetation to prevent erosion may be difficult. The local Soil Conservation Service Office or County Extension Office can provide information on any special measures necessary to promote the establishment of vegetation.

4.5.1 Vegetative Practices

Preserving existing vegetation or revegetating disturbed soil as soon as possible after construction is the most effective way to control erosion. A vegetation cover reduces erosion potential in four ways: (1) by shielding the soil surface from direct erosive impact of raindrops; (2) by improving the soil's water storage porosity and capacity so more water can infiltrate into the ground; (3) by slowing the runoff and allowing the sediment to drop out or deposit; and (4) by physically holding the soil in place with plant roots.

Vegetative cover can be grass, trees, shrubs, bark, mulch, or straw. Grasses are the most common type of cover used for revegetation because they grow quickly, providing erosion protection within days. Other soil stabilization practices such as straw or mulch may be used during non-growing seasons to prevent erosion. Newly planted shrubs and trees establish root systems more slowly, so keeping existing ones is a more effective practice.

Vegetative and other site stabilization practices can be either temporary or permanent controls. Temporary controls provide a cover for exposed or disturbed areas for short periods of time or until permanent erosion controls are put in place. Permanent vegetative practices are used when activities that disturb the soil are completed or when erosion is occurring on a site that is otherwise stabilized. The remainder of this section describes the common vegetative practices listed below:

- Preservation of Natural Vegetation
- Buffer Zones
- Stream Bank Stabilization
- Mulching, Matting, and Netting
- Temporary Seeding
- Permanent Seeding and Planting
- Sodding
- Chemical Stabilization.

Preservation of Natural Vegetation

What Is It

The preservation of natural vegetation (existing trees, vines, brushes, and grasses) provides natural buffer zones. By preserving stabilized areas, it minimizes erosion potential, protects water quality, and provides aesthetic benefits. This practice is used as a permanent control measure.

When and Where to Use It

This technique is applicable to all types of sites. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain.

What to Consider

Preservation of vegetation on a site should be planned before any site disturbance begins. Preservation requires good site management to minimize the impact of construction activities on existing vegetation. Clearly mark the trees to be preserved and protect them from ground disturbances around the base of the tree. Proper maintenance is important to ensure healthy vegetation that can control erosion. Different species, soil types, and climatic conditions will require different maintenance activities such as mowing, fertilizing, liming, irrigation, pruning, and weed and pest control. Some State/local regulations require natural vegetation to be preserved in sensitive areas; consult the appropriate State/local agencies for more information on their regulations. Maintenance should be performed regularly, especially during construction.

Advantages of Preservation of Natural Vegetation
• Can handle higher quantities of storm water runoff than newly seeded areas • Does not require time to establish (i.e., effective immediately) • Increases the filtering capacity because the vegetation and root structure are usually denser in preserved natural vegetation than in newly seeded or base areas • Enhances aesthetics • Provides areas for infiltration, reducing the quantity and velocity of storm water runoff • Allows areas where wildlife can remain undisturbed • Provides noise buffers and screens for onsite operations • Usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation
Disadvantages of Preservation of Natural Vegetation
• Requires planning to preserve and maintain the existing vegetation • May not be cost effective with high land costs • May constrict area available for construction activities

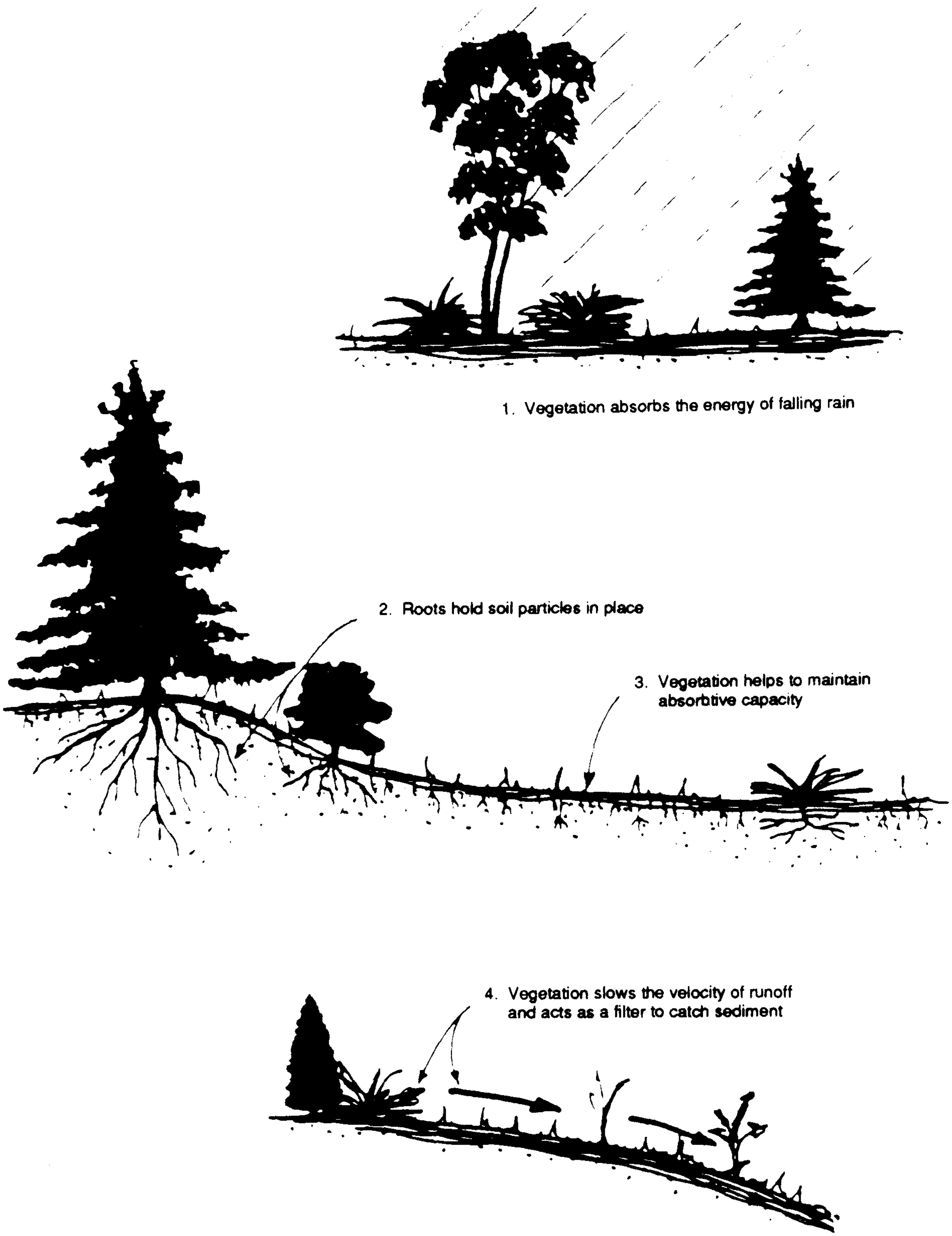


FIGURE 4.10 BENEFITS OF PRESERVING NATURAL VEGETATION
(Modified from Washington State, 1992)

Buffer Zones

What Are They

Buffer zones are vegetated strips of land used for temporary or permanent water quality benefits. Buffer zones are used to decrease the velocity of storm water runoff, which in turn helps to prevent soil erosion. Buffer zones are different from vegetated filter strips (see section on Vegetated Filter Strips) because buffer zone effectiveness is not measured by its ability to improve infiltration (allow water to go into the ground). The buffer zone can be an area of vegetation that is left undisturbed during construction, or it can be newly planted.

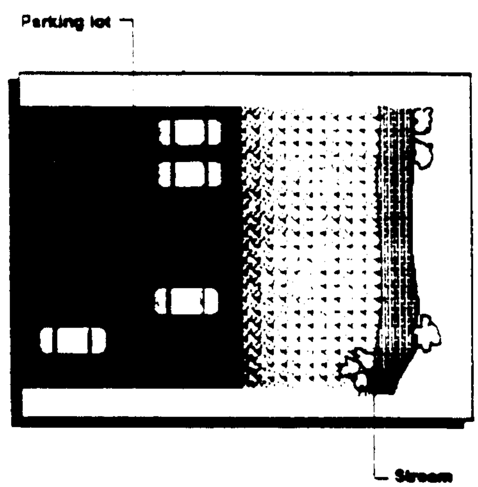


FIGURE 4.11 EXAMPLE BUFFER ZONE (Modified from Washington State, 1992)

When and Where to Use Them

Buffer zones technique can be used at any site that can support vegetation. Buffer zones are particularly effective on floodplains, next to wetlands, along stream banks, and on steep, unstable slopes.

What to Consider

If buffer zones are preserved, existing vegetation, good planning, and site management are needed to protect against disturbances such as grade changes, excavation, damage from equipment, and other activities. Establishing new buffer strips requires the establishment of a good dense turf, trees, and shrubs (see Permanent Seeding and Planting). Careful maintenance is important to ensure healthy vegetation. The need for routine maintenance such as mowing, fertilizing, liming, irrigating, pruning, and weed and pest control will depend on the species of plants and trees involved, soil types, and climatic conditions. Maintaining planted areas may require debris removal and protection against unintended uses or traffic. Many State/local storm water program or zoning agencies have regulations which define required or allowable buffer zones especially near sensitive areas such as wetlands. Contact the appropriate State/local agencies for their requirements.

Advantages of Buffer Zones
• Provide aesthetic as well as water quality benefits • Provide areas for infiltration, which reduces amount and speed of storm water runoff • Provide areas for wildlife habitat • Provide areas for recreation • Provide buffers and screens for onsite noise if trees or large bushes are used • Low maintenance requirements • Low cost when using existing vegetation
Disadvantages of Buffer Zones
• May not be cost effective to use if the cost of land is high • Are not feasible if land is not available • Require plant growth before they are effective

Stream Bank Stabilization

What Is It

Stream bank stabilization is used to prevent stream bank erosion from high velocities and quantities of storm water runoff. Typical methods include the following:

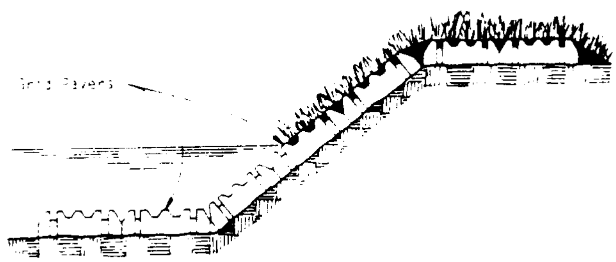
- **Riprap**–Large angular stones placed along the stream bank or lake
- **Gabion**–Rock-filled wire cages that are used to create a new stream bank
- **Reinforced Concrete**–Concrete bulkheads and retaining walls that replace natural stream banks and create a nonerosive surface
- **Log Cribbing**–Retaining walls built of logs to anchor the soils against erosive forces. Usually built on the outside of stream bends
- **Grid Pavers**–Precast or poured-in-place concrete units that are placed along stream banks to stabilize the stream bank and create open spaces where vegetation can be established
- **Asphalt**–Asphalt paving that is placed along the natural stream bank to create a nonerosive surface.

When and Where to Use It

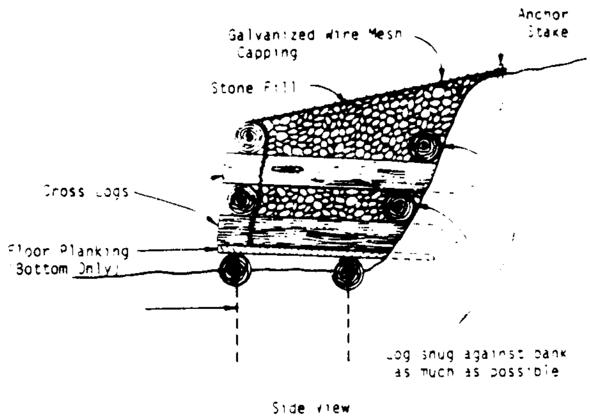
Stream bank stabilization is used where vegetative stabilization practices are not practical and where the stream banks are subject to heavy erosion from increased flows or disturbance during construction. Stabilization should occur before any land development in the watershed area. Stabilization can also be retrofitted when erosion of a stream bank occurs.

What to Consider

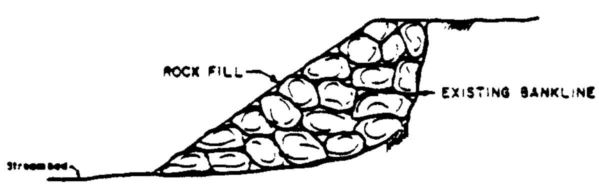
Stream bank stabilization structures should be planned and designed by a professional engineer licensed in the State where the site is located. Applicable Federal, State, and local requirements should be followed, including Clean Water Act Section 404 regulations. An important design feature of stream bank stabilization methods is the foundation of the structure; the potential for the stream to erode the sides and bottom of the channel should be considered to make sure the stabilization measure will be supported properly. Structures can be designed to protect and improve natural wildlife habitats; for example, log structures and grid pavers can be designed to keep vegetation. Only pressure-treated wood should be used in log structures. Permanent structures should be designed to handle expected flood conditions. A well-designed layer of stone can be used in many ways and in many locations to control erosion and sedimentation. Riprap protects soil from erosion and is often used on steep slopes built with fill materials that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, stream bank protection, and protection of shore lines subject to wave action. It is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. It is used to expose the water to air as well as to reduce water energy. Riprap and gabion (wire mesh cages filled with rock) are usually placed over a filter blanket (i.e., a gravel layer or filter cloth). Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer throughout the stream. Reinforced concrete structures may require positive



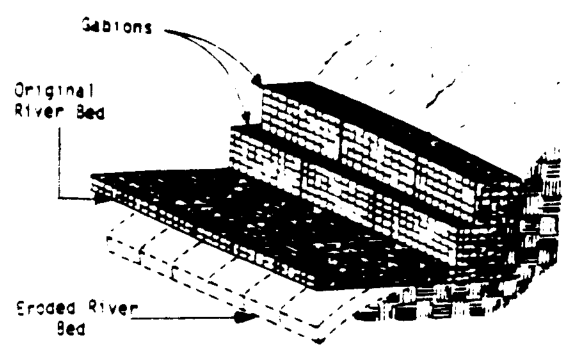
Grid Pavers



Log Cribbing



Riprap



Gabion

FIGURE 4.12 EXAMPLES OF STREAM BANK STABILIZATION PRACTICES
(Modified from Commonwealth of Virginia, 1980, and Commonwealth of Pennsylvania, 1990)

drainage behind the bulkhead or retaining wall to prevent erosion around the structure. Gabion and grid pavers should be installed according to manufacturers' recommendations.

Stream bank stabilization structures should be inspected regularly and after each large storm event. Structures should be maintained as installed. Structural damage should be repaired as soon as possible to prevent further damage or erosion to the stream bank.

Advantages of Stream Bank Stabilization
• Can provide control against erosive forces caused by the increase in storm water flows created during land development • Usually will not require as much maintenance as vegetative erosion controls • May provide wildlife habitats • Forms a dense, flexible, self-healing cover that will adapt well to uneven surfaces (riprap)
Disadvantages of Stream Bank Stabilization
• Does not provide the water quality or aesthetic benefits that vegetative practices could • Should be designed by qualified professional engineers, which may increase project costs • May be expensive (materials costs) • May require additional permits for structure • May alter stream dynamics which cause changes in the channel downstream • May cause negative impacts to wildlife habitats

Mulching, Matting, and Netting

What Are They

Mulching is a temporary soil stabilization or erosion control practice where materials such as grass, hay, woodchips, wood fibers, straw, or gravel are placed on the soil surface. In addition to stabilizing soils, mulching can reduce the speed of storm water runoff over an area. When used together with seeding or planting, mulching can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by preventing birds from eating seeds, helping to retain moisture, and by insulating against extreme temperatures. Mulch mattings are materials (jute or other wood fibers) that have been formed into sheets of mulch that are more stable than normal mulch. Netting is typically made from jute, other wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well. Mulch binders (either asphalt or synthetic) are sometimes used instead of netting to hold loose mulches together.

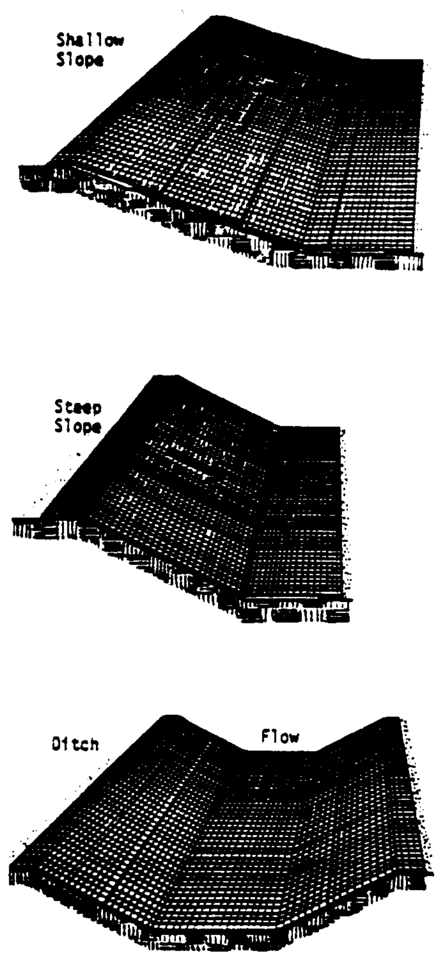


FIGURE 4.13 ORIENTATION OF MULCH NETTING AND MATTING (Modified from County of Fairfax, 1987)

When and Where to Use Them

Mulching is often used alone in areas where temporary seeding cannot be used because of the season or climate. Mulching can provide immediate, effective, and inexpensive erosion control. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place.

Mulch seeded and planted areas where slopes are steeper than 2:1, where runoff is flowing across the area, or when seedlings need protection from bad weather.

What to Consider

Use of mulch may or may not require a binder, netting, or the tacking of mulch to the ground. Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will occur underneath the material. Final grading is not necessary before mulching. Mulched areas should be inspected often to find where mulched material has been loosened or removed. Such areas should be reseeded (if necessary) and the mulch cover replaced immediately. Mulch binders should be applied at rates recommended by the manufacturer or, if asphalt is used, at rates of approximately 480 gallons per acre (Arapahoe County, 1988).

Advantages of Mulching, Matting, and Netting
• Provide immediate protection to soils that are exposed and that are subject to heavy erosion • Retain moisture, which may minimize the need for watering • Require no removal because of natural deterioration of mulching and matting
Disadvantages of Mulching, Matting, and Netting
• May delay germination of some seeds because cover reduces the soil surface temperature • Netting should be removed after usefulness is finished, then landfilled or composted

Temporary Seeding

What Is It

Temporary seeding means growing a short-term vegetative cover (plants) on disturbed site areas that may be in danger of erosion. The purpose of temporary seeding is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be stabilized for long periods of time or where permanent plant growth is not necessary or appropriate. This practice uses fast-growing grasses whose root systems hold down the soils so that they are less apt to be carried offsite by storm water runoff or wind. Temporary seeding also reduces the problems associated with mud and dust from bare soil surfaces during construction.

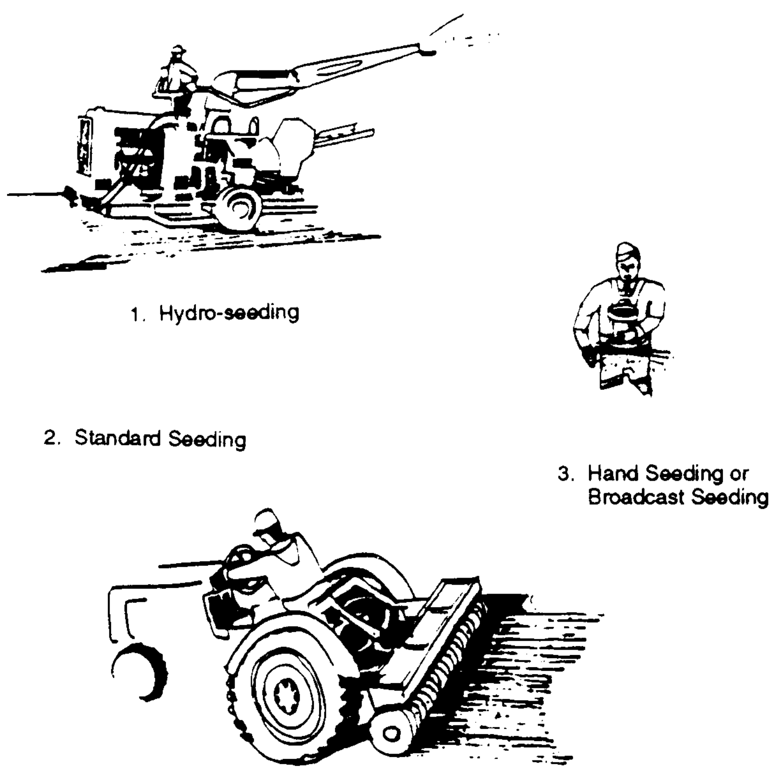


FIGURE 4.14 SEEDING PRACTICES
(Modified from Washington State, 1992)

When and Where to Use It

Temporary seeding should be performed on areas which have been disturbed by construction and which are likely to be redisturbed, but not for several weeks or more. Typical areas might include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, and temporary roadbanks. Temporary seeding should take place as soon as practicable after the last land disturbing activity in an area. Check the requirements of your permit for the maximum amount of time allowed between the last disturbance of an area and temporary stabilization. Temporary seeding may not be an effective practice in arid and semi-arid regions where the climate prevents fast plant growth, particularly during the dry seasons. In those areas, mulching or chemical stabilization may be better for the short-term (see sections on Mulching, Geotextiles, and Chemical Stabilization).

What to Consider

Proper seed bed preparation and the use of high-quality seed are needed to grow plants for effective erosion control. Soil that has been compacted by heavy traffic or machinery may need to be loosened. Successful growth usually requires that the soil be tilled before the seed is applied. Topsoiling is not necessary for temporary seeding; however, it may improve the chances of establishing temporary vegetation in an area. Seed bed preparation may also require applying fertilizer and/or lime to the soil to make conditions more suitable for plant growth. Proper fertilizer, seeding mixtures, and seeding rates vary depending on the location of the site, soil types, slopes, and season. Local suppliers, State and local regulatory agencies, and the USDA Soil Conservation Service will supply information on the best seed mixes and soil conditioning methods.

Seeded areas should be covered with mulch to provide protection from the weather. Seeding on slopes of 2:1 or more, in adverse soil conditions, during excessively hot or dry weather, or where heavy rain is expected should be followed by spreading mulch (see section on Mulching). Frequent inspections are necessary to check that conditions for growth are good. If the plants do not grow quickly or thick enough to prevent erosion, the area should be reseeded as soon as possible. Seeded areas should be kept adequately moist. If normal rainfall will not be enough, mulching, matting, and controlled watering should be done. If seeded areas are watered, watering rates should be watched so that over-irrigation (which can cause erosion itself) does not occur.

Advantages of Temporary Seeding
• Is generally inexpensive and easy to do • Establishes plant cover fast when conditions are good • Stabilizes soils well, is aesthetic, and can provide sedimentation controls for other site areas • May help reduce costs of maintenance on other erosion controls (e.g., sediment basins may need to be cleaned out less often)
Disadvantages of Temporary Seeding
• Depends heavily on the season and rainfall rate for success • May require extensive fertilizing of plants grown on some soils, which can cause problems with local water quality • Requires protection from heavy use, once seeded • May produce vegetation that requires irrigation and maintenance

Permanent Seeding and Planting

What Is It

Permanent seeding of grass and planting trees and brush provides stabilization to the soil by holding soil particles in place. Vegetation reduces sediments and runoff to downstream areas by slowing the velocity of runoff and permitting greater infiltration of the runoff. Vegetation also filters sediments, helps the soil absorb water, improves wildlife habitats, and enhances the aesthetics of a site.

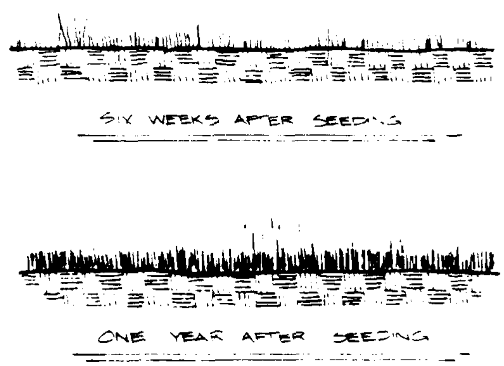


FIGURE 4.15 ESTABLISHING PERMANENT COVER WITH VEGETATION
(Modified from State of North Carolina, 1988)

When and Where to Use It

Permanent seeding and planting is appropriate for any graded or cleared area where long-lived plant cover is desired. Some areas where permanent seeding is especially important are filter strips, buffer areas, vegetated swales, steep slopes, and stream banks. This practice is effective on areas where soils are unstable because of their texture, structure, a high water table, high winds, or high slope. When seeding in northern areas during fall or winter, cover the area with mulch to provide a protective barrier against cold weather (see Mulching). Seeding should also be mulched if the seeded area slopes 4:1 or more, if soil is sandy or clayey, or if weather is excessively hot or dry. Plant when conditions are most favorable for growth. When possible, use low-maintenance local plant species. Install all other erosion control practices such as dikes, basins, and surface runoff control measures before planting.

What to Consider

For this practice to work, it is important to select appropriate vegetation, prepare a good seedbed, properly time planting, and water and fertilize. Planting local plants during their regular growing season will increase the chances for success and may lessen the need for watering. Check seeded areas frequently for proper watering and growth conditions.

Topsoil should be used on areas where topsoils have been removed, where the soils are dense or impermeable, or where mulching and fertilizers alone cannot improve soil quality. Topsoiling should be coordinated with the seeding and planting practices and should not be planned while the ground is frozen or too wet. Topsoil layers should be at least 2 inches deep (or similar to the existing topsoil depth).

To minimize erosion and sedimentation, remove as little existing topsoil as possible. All site controls should be in place before the topsoil is removed. If topsoils are brought in from another site, it is important that its texture is compatible with the subsoils onsite; for example, sandy topsoils are not compatible with clay subsoils.

Stockpiling of topsoils onsite requires good planning so soils will not obstruct other operations. If soil is to be stockpiled, consider using temporary seeding, mulching, or silt fencing to prevent or control erosion. Inspect the stockpiles frequently for erosion. After topsoil has been spread, inspect it regularly, and reseed or replace areas that have eroded.

Advantages of Permanent Seeding and Planting
• Improves the aesthetics of a site • Provides excellent stabilization • Provides filtering of sediments • Provides wildlife habitat • Is relatively inexpensive
Disadvantages of Permanent Seeding and Planting
• May require irrigation to establish vegetation • Depends initially on climate and weather for success

Sodding

What Is It

Sodding stabilizes an area by establishing permanent vegetation, providing erosion and sedimentation controls, and providing areas where storm water can infiltrate the ground.

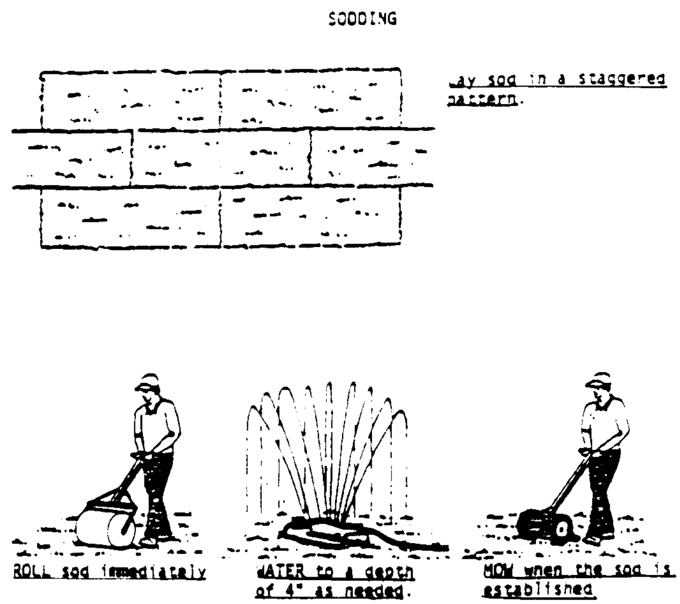


FIGURE 4.16 SODDING
(Modification from County of Fairfax, 1987)

When and Where to Use It

Sodding is appropriate for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. Examples of where sodding can be used are buffer zones, stream banks, dikes, swales, slopes, outlets, level spreaders, and filter strips.

What to Consider

The soil surface should be fine-graded before laying down the sod. Topsoil may be needed in areas where the soil textures are inadequate (see topsoil discussion in section on Permanent Seeding and Planting). Lime and fertilizers should be added to the soil to promote good growth conditions. Sodding can be applied in alternating strips or other patterns, or alternate areas can be seeded to reduce expense. Sod should not be planted during very hot or wet weather. Sod should not be placed on slopes that are greater than 3:1 if they are to be mowed. If placed on steep slopes, sod should be laid with staggered joints and/or be pegged. In areas such as steep slopes or next to running waterways, chicken wire, jute, or other netting can be placed over the sod for extra protection against lifting (see Mulching, Matting, and Netting). Rolled or compact immediately after installation to ensure firm contact with the underlying topsoil. Inspect the sod frequently after it is first installed, especially after large storm events, until it is established as permanent cover. Remove and replace dead sod. Watering may be necessary after planting and during periods of intense heat and/or lack of rain.

Advantages of Sodding
• Can provide immediate vegetative cover and erosion control • Provides more stabilizing protection than initial seeding through dense cover formed by sod • Produces lower weed growth than seeded vegetation • Can be used for site activities within a shorter time than can seeded vegetation • Can be placed at any time of the year as long as moisture conditions in the soil are favorable, except when the ground is frozen
Disadvantages of Sodding
• Purchase and installation costs are higher than for seeding • May require continued irrigation if the sod is placed during dry seasons or on sandy soils

Chemical Stabilization

What Is It

Chemical stabilization practices, often referred to as a chemical mulch, soil binder, or soil palliative, are temporary erosion control practices. Materials made of vinyl, asphalt, or rubber are sprayed onto the surface of the soil to hold the soil in place and protect against erosion from storm water runoff and wind. Many of the products used for chemical stabilization are human-made, and many different products are on the market.

When and Where to Use It

Chemical stabilization can be used as an alternative in areas where temporary seeding practices cannot be used because of the season or climate. It can provide immediate, effective, and inexpensive erosion control anywhere erosion is occurring on a site.

What to Consider

The application rates and procedures recommended by the manufacturer of a chemical stabilization product should be followed as closely as possible to prevent the products from forming ponds and from creating large areas where moisture cannot get through.

Advantages of Chemical Stabilization
• Is easily applied to the surface of the soil • Is effective in stabilizing areas where plants will not grow • Provides immediate protection to soils that are in danger of erosion
Disadvantages of Chemical Stabilization
• Can create impervious surfaces (where water cannot get through), which may in turn increase the amount and speed of storm water runoff • May cause harmful effects on water quality if not used correctly • Is usually more expensive than vegetative cover

4.5.2 Structural Erosion Prevention and Sediment Control Practices

Structural practices used in sediment and erosion control divert storm water flows away from exposed areas, convey runoff, prevent sediments from moving offsite, and can also reduce the erosive forces of runoff waters. The controls can either be used as permanent or temporary measures. Practices discussed include the following:

- Interceptor Dikes and Swales
- Pipe Slope Drains
- Subsurface Drains
- Filter Fence
- Straw Bale Barrier
- Brush Barrier
- Gravel or Stone Filter Berm
- Storm Drain Inlet Protection
- Sediment Trap
- Temporary Sediment Basin
- Outlet Protection
- Check Dams
- Surface Roughening
- Gradient Terraces.

Interceptor Dikes and Swales

What Are They

Interceptor dikes (ridges of compacted soil) and swales (excavated depressions) are used to keep upslope runoff from crossing areas where there is a high risk of erosion. They reduce the amount and speed of flow and then guide it to a stabilized outfall (point of discharge) (see section on Outlet Protection) or sediment trapping area (see sections on Level Spreaders, Vegetated Filter Strips, Sediment Traps, and Temporary Sediment Basins). Interceptor dikes and swales divert runoff using a combination of earth dike and vegetated swale. Runoff is channeled away from locations where there is a high risk of erosion by placing a diversion dike or swale at the top of a sloping disturbed area. Dikes and swales also collect overland flow, changing it into concentrated flows (i.e., flows that are combined). Interceptor dikes and swales can be either temporary or permanent storm water control structures.

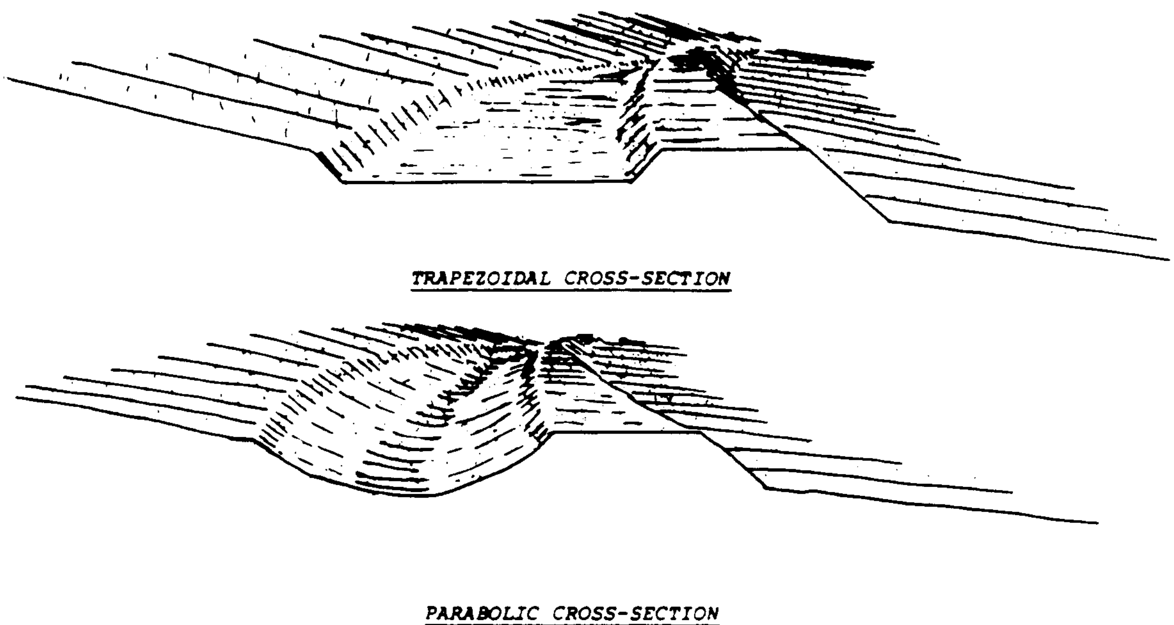


FIGURE 4.17 TYPICAL INTERCEPTOR DIKES AND SWALES
(Modified from State of Maryland, 1983)

When and Where to Use Them

Interceptor dikes and swales are generally built around the perimeter of a construction site before any major soil disturbing activity takes place. Temporary dikes or swales may also be used to protect existing buildings; areas, such as stockpiles; or other small areas that have not yet been fully stabilized. When constructed along the upslope perimeter of a disturbed or high-risk area (though not necessarily all the way around it), dikes or swales prevent runoff from uphill areas from crossing the unprotected slope. Temporary dikes or swales constructed on the down slope side of the disturbed or high-risk area will prevent runoff that contains sediment from leaving the site before sediment is removed. For short slopes, a dike or swale at the top of the slope reduces the amount of runoff reaching the disturbed area. For longer slopes, several dikes or swales are placed across the slope at intervals. This practice reduces the amount of runoff that accumulates on the face of the slope and carries the runoff safely down the slope. In all cases, runoff is guided to a sediment trapping area or a stabilized outfall before release.

What to Consider

Temporary dikes and swales are used in areas of overland flow; if they remain in place longer than 15 days, they should be stabilized. Runoff channeled by a dike or swale should be directed to an adequate sediment trapping area or stabilized outfall. Care should be taken to provide enough slope for drainage but not too much slope to cause erosion due to high runoff flow speed. Temporary interceptor dikes and swales may remain in place as long as 12 to 18 months (with proper stabilization) or be rebuilt at the end of each day's activities. Dikes or swales should remain in place until the area they were built to protect is permanently stabilized. Interceptor dikes and swales can be permanent controls. However, permanent controls: should be designed to handle runoff after construction is complete; should be permanently stabilized; and should be inspected and maintained on a regular basis. Temporary and permanent control measures should be inspected once each week on a regular schedule and after every storm. Repairs necessary to the dike and flow channel should be made promptly.

Advantages of Interceptor Dikes and Swales
• Are simple and effective for channeling runoff away from areas subject to erosion • Can handle flows from large drainage areas • Are inexpensive because they use materials and equipment normally found onsite
Disadvantages of Interceptor Dikes and Swales
• If constructed improperly, can cause erosion and sediment transport since flows are conce ·rated • May cause problems to vegetation growth if water flow is too fast • Require additional maintenance, inspections, and repairs

Pipe Slope Drains

What Are They

Pipe slope drains reduce the risk of erosion by discharging runoff to stabilized areas. Made of flexible or rigid pipe, they carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. They are also used to drain saturated slopes that have the potential for soil slides. Pipe slope drains can be either temporary or permanent depending on the method of installation and material used.

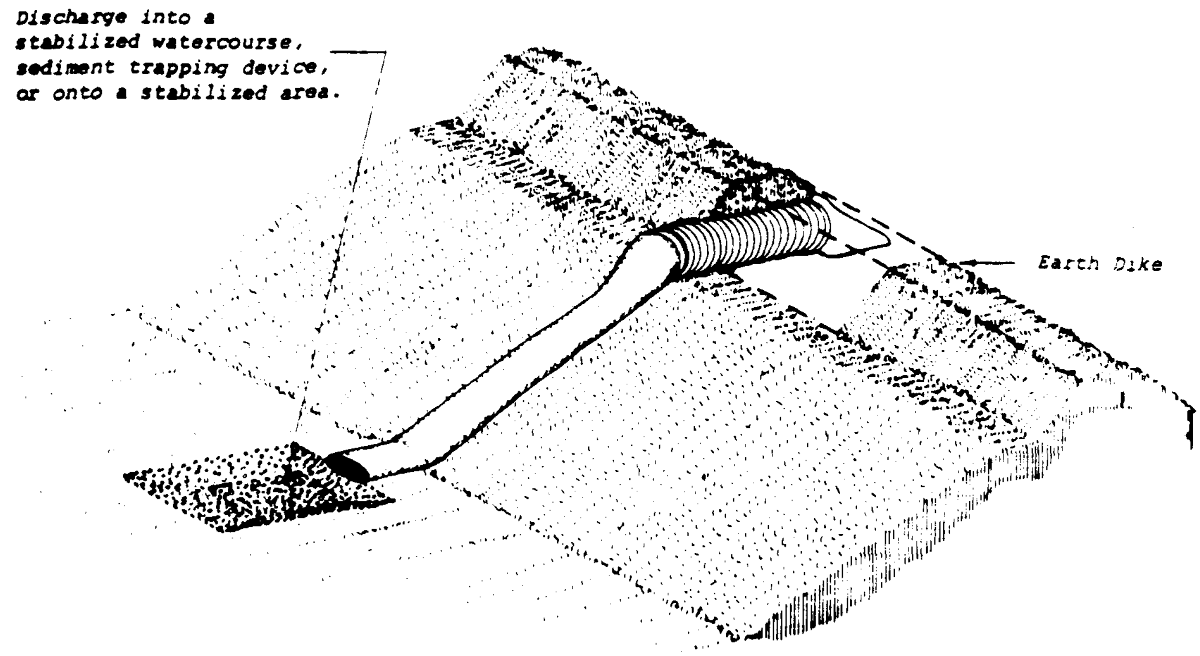


FIGURE 4.18 FLEXIBLE PIPE SLOPE DRAIN (Modified from State of Maryland, 1983)

When and Where to Use Them

Pipe slope drains are used whenever it is necessary to convey water down a slope without causing erosion. They are especially effective before a slope has been stabilized or before permanent drainage structures are ready for use. Pipe slope drains may be used with other devices, including diversion dikes or swales, sediment traps, and level spreaders (used to spread out storm water runoff uniformly over the surface of the ground). Temporary pipe slope drains, usually flexible tubing or conduit, may be installed prior to the construction of permanent drainage structures. Permanent slope drains may be placed on or beneath the ground surface; pipes, sectional downdrains, paved chutes, or clay tiles may be used.

Paved chutes may be covered with a surface of concrete or other impenetrable material. Subsurface drains can be constructed of concrete, PVC, clay tile, corrugated metal, or other permanent material.

What to Consider

The drain design should be able to handle the volume of flow. The effective life span of a temporary pipe slope drain is up to 30 days after permanent stabilization has been achieved. The maximum recommended drainage area for pipe slope drains is 10 acres (Washington State, 1992).

The inlets and outlets of a pipe slope drain should be stabilized. This means that a flared end section should be used at the entrance of the pipe. The soil around the pipe entrance should be fully compacted. The soil at the discharge end of the pipe should be stabilized with riprap (a combination of large stones, cobbles, and boulders). The riprap should be placed along the bottom of a swale which leads to a sediment trapping structure or another stabilized area.

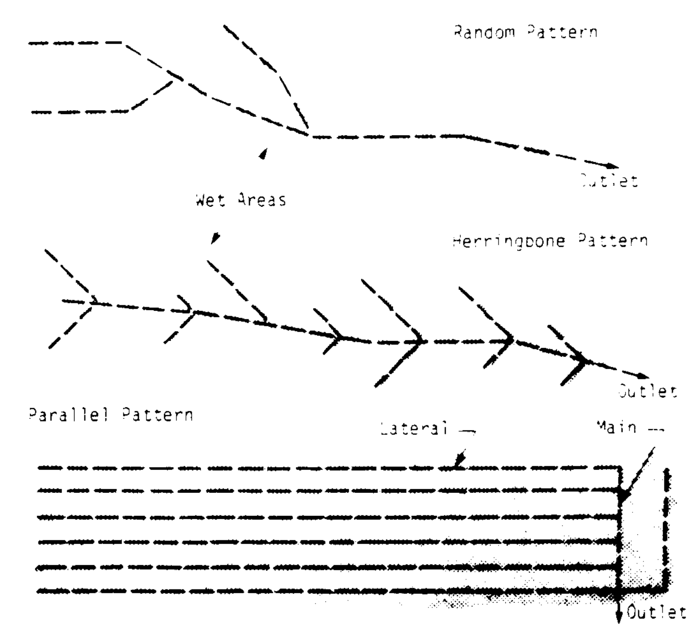
Pipe slope drains should be inspected on a regular schedule and after any major storm. Be sure that the inlet from the pipe is properly installed to prevent bypassing the inlet and undercutting the structure. If necessary, install a headwall, riprap, or sandbags around the inlet. Check the outlet point for erosion and check the pipe for breaks or clogs. Install outlet protection if needed and promptly clear breaks and clogs.

Advantages of Pipe Slope Drains
• Can reduce or eliminate erosion by transporting runoff down steep slopes or by draining saturated soils • Are easy to install and require little maintenance
Disadvantages of Pipe Slope Drains
• Require that the area disturbed by the installation of the drain should be stabilized or it, too, will be subject to erosion • May clog during a large storm

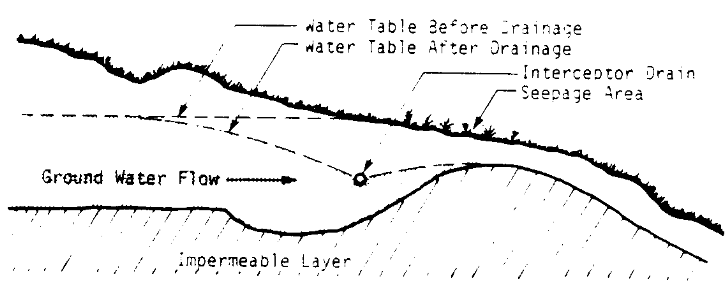
Subsurface Drains

What Are They

A subsurface drain is a perforated pipe or conduit placed beneath the surface of the ground at a designed depth and grade. It is used to drain an area by lowering the water table. A high water table can saturate soils and prevent the growth of certain types of vegetation. Saturated soils on slopes will sometimes "slip" down the hill. Installing subsurface drains can help prevent these problems.



Typical Subsurface Drain Patterns



Effect of Subsurface Drains on Water Table

FIGURE 4.19 SUBSURFACE DRAINS
(Modified from Commonwealth of Virginia, 1980)

When and Where to Use Them

There are two types of subsurface drains: relief drains and interceptor drains. Relief drains are used to dewater an area where the water table is high. They may be placed in a gridiron, herringbone, or random pattern. Interceptor drains are used to remove water where sloping soils are excessively wet or subject to slippage. They are usually placed as single pipes instead of in patterns. Generally, subsurface drains are suitable only in areas where the soil is deep enough for proper installation. They are not recommended where they pass under heavy vehicle crossings.

What to Consider

Drains should be placed so that tree roots will not interfere with drainage pipes. The drain design should be adequate to handle the volume of flow. Areas disturbed by the installation of a drain should be stabilized or they, too, will be subject to erosion. The soil layer must be deep enough to allow proper installation.

Backfill immediately after the pipe is placed. Material used for backfill should be open granular soil that is highly permeable. The outlet should be stabilized and should direct sediment-laden storm water runoff to a sediment trapping structure or another stabilized area.

Inspect subsurface drains on a regular schedule and check for evidence of pipe breaks or clogging by sediment, debris, or tree roots. Remove blockage immediately, replace any broken sections, and restabilize the surface. If the blockage is from tree roots, it may be necessary to relocate the drain. Check inlets and outlets for sediment or debris. Remove and dispose of these materials properly.

Advantages of Subsurface Drains
• Provide an effective method for stabilizing wet sloping soils
• Are an effective way to lower the water table
Disadvantages of Subsurface Drains
• May be pierced and clogged by tree roots
• Should not be installed under heavy vehicle crossings
• Cost more than surface drains because of the expenses of excavation for installation

Filter Fence

What Is It

A silt fence, also called a "filter fence," is a temporary measure for sedimentation control. It usually consists of posts with filter fabric stretched across the posts and sometimes with a wire support fence. The lower edge of the fence is vertically trenched and covered by backfill. A silt fence is used in small drainage areas to detain sediment. These fences are most effective where there is overland flow (runoff that flows over the surface of the ground as a thin, even layer) or in minor swales or drainageways. They prevent sediment from entering receiving waters. Silt fences are also used to catch wind blown sand and to create an anchor for sand dune creation. Aside from the traditional wooden post and filter fabric method, there are several variations of silt fence installation including silt fence which can be purchased with pockets presewn to accept use of steel fence posts.

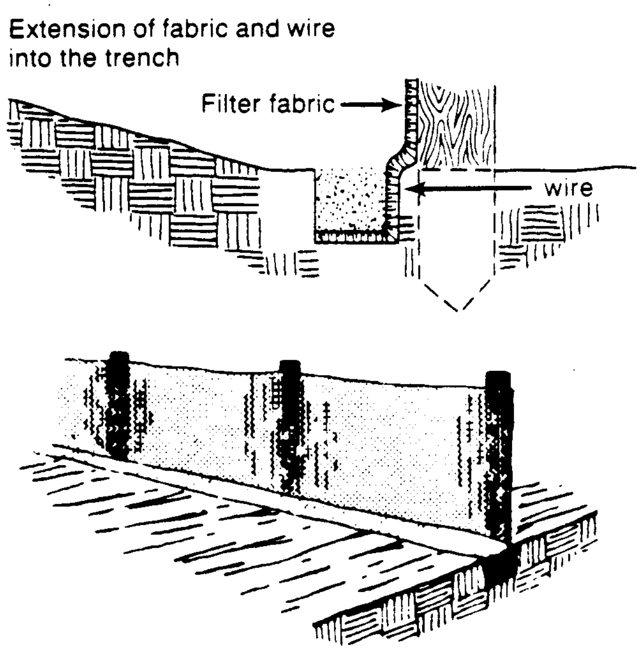


FIGURE 4.20 FILTER FENCE DETAILS
(Modified from State of North Carolina, 1988; and State of Wisconsin, 1988)

When and Where to Use It

A silt fence should be installed prior to major soil disturbance in the drainage area. Such a structure is only appropriate for drainage areas of 1 acre or less with velocities of 0.5 cfs or less (Washington State, 1992). The fence should be placed across the bottom of a slope or minor drainageway along a line of uniform elevation (perpendicular to the direction of flow). It can be used at the outer boundary of the work area. However, the fence does not have to surround the work area completely. In addition, a silt fence is effective where sheet and rill erosion may be a problem. Silt fences should not be constructed in streams or swales.

What to Consider

A silt fence is not appropriate for a large area or where the flow rate is greater than 0.5 cfs. This type of fence can be more effective than a straw bale barrier if properly installed and maintained. It may be used in combination with other erosion and sediment practices.

The effective life span for a silt fence is approximately 6 months. During this period, the fence requires frequent inspection and prompt maintenance to maintain its effectiveness. Inspect the fence after each rainfall. Check for areas where runoff eroded a channel beneath the fence, or where the fence was caused to sag or collapse by runoff flowing over the top. Remove and properly dispose of sediment when it is one-third to one-half the height of the fence or after each storm.

Advantages of a Filter Fence
• Removes sediments and prevents downstream damage from sediment deposits • Reduces the speed of runoff flow • Minimal clearing and grubbing required for installation • Inexpensive
Disadvantages of a Filter Fence
• May result in failure from improper choice of pore size in the filter fabric or improper installation • Should not be used in streams • Is only appropriate for small drainage areas with overland flow • Frequent inspection and maintenance is necessary to ensure effectiveness

Straw Bale Barrier

What Is It

Straw bales can be used as a temporary sediment barrier. They are placed end to end in a shallow excavated trench (with no gaps in between) and staked into place. If properly installed, they can detain sediment and reduce flow velocity from small drainage areas. A straw bale barrier prevents sediment from leaving the site by trapping the sediment in the barrier while allowing the runoff to pass through. It can also be used to decrease the velocity of sheetflow or channel flows of low-to-moderate levels.

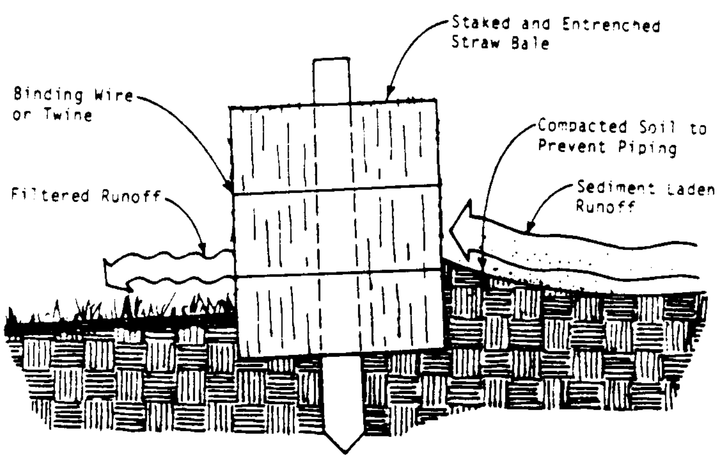


FIGURE 4.21 CROSS SECTION OF A PROPERLY INSTALLED STRAW BALE BARRIER (Modified from State of Wisconsin, 1988)

When and Where to Use It

A straw bale barrier should be installed prior to major soil disturbance in the drainage area. This type of barrier is placed perpendicular to the flow, across the bottom of a slope or minor drainageway where there is sheetflow. It can be used at the perimeter of the work area, although is does not have to surround it completely. It can also be very effective when used in combination with other erosion and sediment control practices. A straw bale barrier may be used where the length of slope behind the barrier is less than 100 feet and where the slope is less than 2:1.

What to Consider

The success of a straw bale barrier depends on proper installation. The bales must be firmly staked into the entrenchment and the entrenchment must be properly backfilled. To function effectively, the bales must be placed end to end and there can be no gaps between the bales.

Straw bale barriers are useful for approximately 3 months. They must be inspected and repaired immediately after each rainfall or daily if there is prolonged rainfall. Damaged straw bales require immediate replacement. After each storm, or on a regular basis, trapped sediments must be removed and disposed of properly.

Advantages of a Straw Bale Barrier
• Can prevent downstream damage from sediment deposits if properly installed, used, and maintained • Can be an inexpensive way to reduce or prevent erosion
Disadvantages of a Straw Bale Barrier
• May not be used in streams or large swales • Poses a risk of washouts if the barrier is installed improperly or a storm is severe • Has a short life span and a high inspection and maintenance requirement • Is appropriate for only small drainage areas • Is easily subject to misuse and can contribute to sediment problems

Brush Barrier

What Is It

A brush barrier is a temporary sediment barrier constructed from materials resulting from onsite clearing and grubbing. It is usually constructed at the bottom perimeter of the disturbed area. Filter fabric is sometimes used as an anchor over the barrier to increase its filtering efficiency. Brush barriers are used to trap and retain small amounts of sediment by intercepting the flow from small areas of soil disturbance.

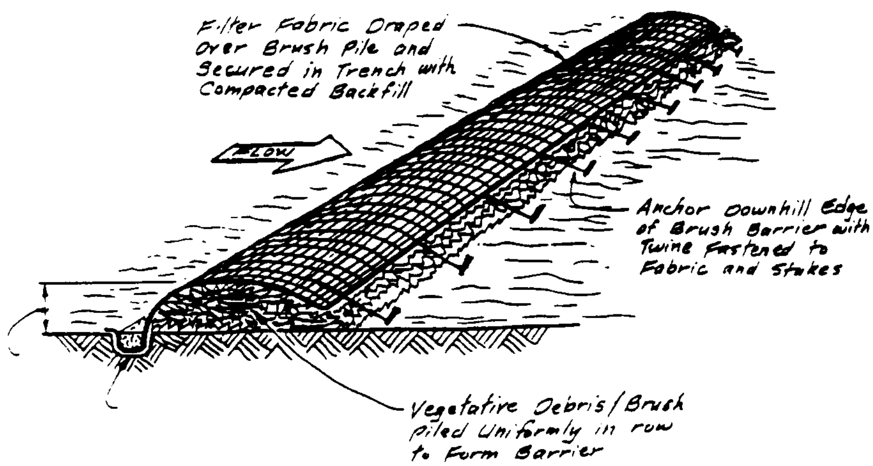


FIGURE 4.22 BRUSH BARRIER
(Modified from Washington State, 1992)

When and Where to Use It

A brush barrier should only be used to trap sediment from runoff which is from a small drainage area. The slope which the brush barrier is placed across should be very gentle. Do not place a brush barrier in a swale or any other channel. Brush barriers should be constructed below areas subject to erosion.

What to Consider

The construction of a brush barrier should be started as soon as clearing and grubbing has produced enough material to make the structure. Wood chips should not be included in the material used for the barrier because of the possibility of leaching. When the site has been stabilized and any excess sediment has been disposed of properly, the filter fabric can be removed. Over time, natural vegetation will establish itself within the barrier, and the barrier itself will decompose.

You will not have to maintain the brush barrier unless there is a very large amount of sediment being deposited. If used, the filter fabric anchor should be checked for tears and the damaged sections replaced promptly. The barrier should be inspected after each rainfall and checked for areas breached by concentrated flow. If necessary, repairs should be made promptly and excess sediment removed and disposed of properly.

Advantages of a Brush Barrier
• Can help prevent downstream damage from sediment deposits • Is constructed of cleared onsite materials and, thus, is inexpensive • Usually requires little maintenance, unless there are very heavy sediment deposits
Disadvantages of a Brush Barrier
• Does not replace a sediment trap or basin • Is appropriate for only small drainage areas • Has very limited sediment retention

Gravel or Stone Filter Berm

What Is It

A gravel or stone filter berm is a temporary ridge constructed of loose gravel, stone, or crushed rock. It slows and filters flow, diverting it from an exposed traffic area. Diversions constructed of compacted soil may be used where there will be little or no construction traffic within the right-of way. They are also used for directing runoff from the right-of-way to a stabilized outlet.

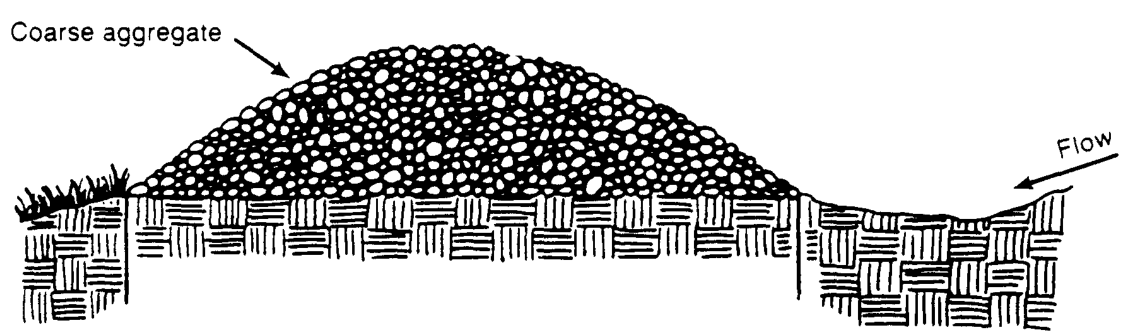


FIGURE 4.23 TYPICAL GRAVEL FILLER BERM
(Modified from Commonwealth of Virginia, 1980)

When and Where to Use It

This method is appropriate where roads and other rights-of-way under construction should accommodate vehicular traffic. Berms are meant for use in areas with shallow slopes. They may also be used at traffic areas within the construction site.

What to Consider

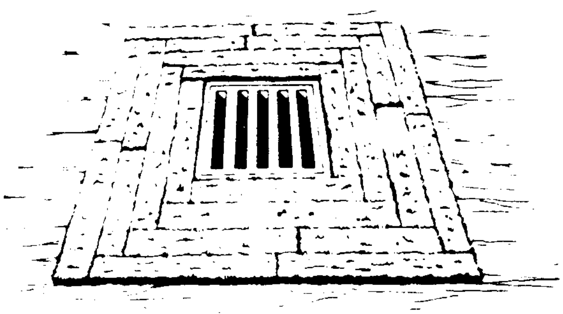
Berm material should be well graded gravel or crushed rock. The spacing of the berms will depend on the steepness of the slope: berms should be placed closer together as the slope increases. The diversion should be inspected daily, after each rainfall, or if breached by construction or other vehicles. All needed repairs should be performed immediately. Accumulated sediment should be removed and properly disposed of and the filter material replaced, as necessary.

Advantages of a Gravel or Stone Filter Berm
• Is a very efficient method of sediment control
Disadvantages of a Gravel or Stone Filter Berm
• Is more expensive than methods that use onsite materials • Has a very limited life span • Can be difficult to maintain because of clogging from mud and soil on vehicle tires

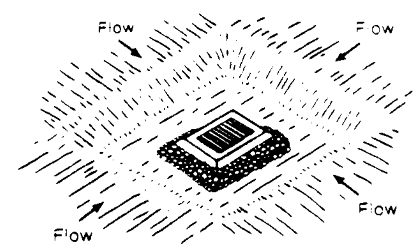
Storm Drain Inlet Protection

What Is It

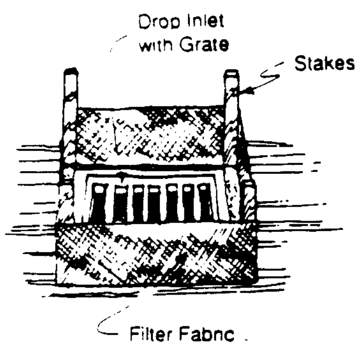
Storm drain inlet protection is a filtering measure placed around any inlet or drain to trap sediment. This mechanism prevents the sediment from entering inlet structures. Additionally, it serves to prevent the silting-in of inlets, storm drainage systems, or receiving channels. Inlet protection may be composed of gravel and stone with a wire mesh filter, block and gravel, filter fabric, or sod.



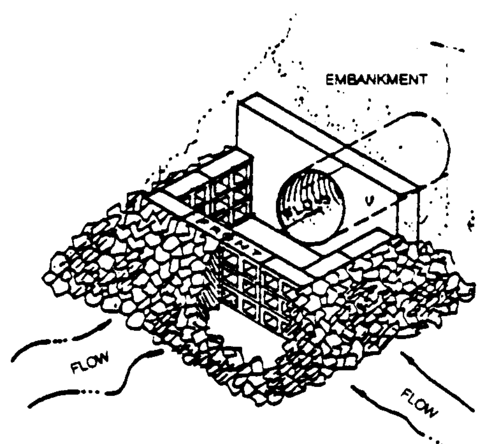
Sod Inlet Protection



Excavated Gravel Inlet Protection



Filter Fabric Inlet Protection



Block and Gravel Inlet Protection

FIGURE 4.24 EXAMPLES OF STORM DRAIN INLET PROTECTION
(Modified from State of North Carolina, 1988; Washington State, 1992; and County of Fairfax, 1987)

When and Where to Use It

This type of protection is appropriate for small drainage areas where storm drain inlets will be ready for use before final stabilization. Storm drain inlet protection is also used where a permanent storm drain structure is being constructed onsite. Straw bales are not recommended for this purpose. Filter fabric is used for inlet protection when storm water flows are relatively small with low velocities. This practice cannot be used where inlets are paved because the filter fabric should be staked. Block and gravel filters can be used where velocities are higher. Gravel and mesh filters can be used where flows are higher and subject to disturbance by site traffic. Sod inlet filters are generally used where sediments in the storm water runoff are low.

What to Consider

Storm drain inlet protection is not meant for use in drainage areas exceeding 1 acre or for large concentrated storm water flows. Installation of this measure should take place before any soil disturbance in the drainage area. The type of material used will depend on site conditions and the size of the drainage area. Inlet protection should be used in combination with other measures, such as small impoundments or sediment traps, to provide more effective sediment removal. Inlet protection structures should be inspected regularly, especially after a rainstorm. Repairs and silt removal should be performed as necessary. Storm drain inlet protection structures should be removed only after the disturbed areas are completely stabilized.

Advantages of Storm Drain Inlet Protection
• Prevents clogging of existing storm drainage systems and the siltation of receiving waters • Reduces the amount of sediment leaving the site
Disadvantages of Storm Drain Inlet Protection
• May be difficult to remove collected sediment • May cause erosion elsewhere if clogging occurs • Is practical only for low sediment, low volume flows

Sediment Trap

What Is It

A sediment trap is formed by excavating a pond or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is constructed using large stones or aggregate to slow the release of runoff. The trap retains the runoff long enough to allow most of the silt to settle out.

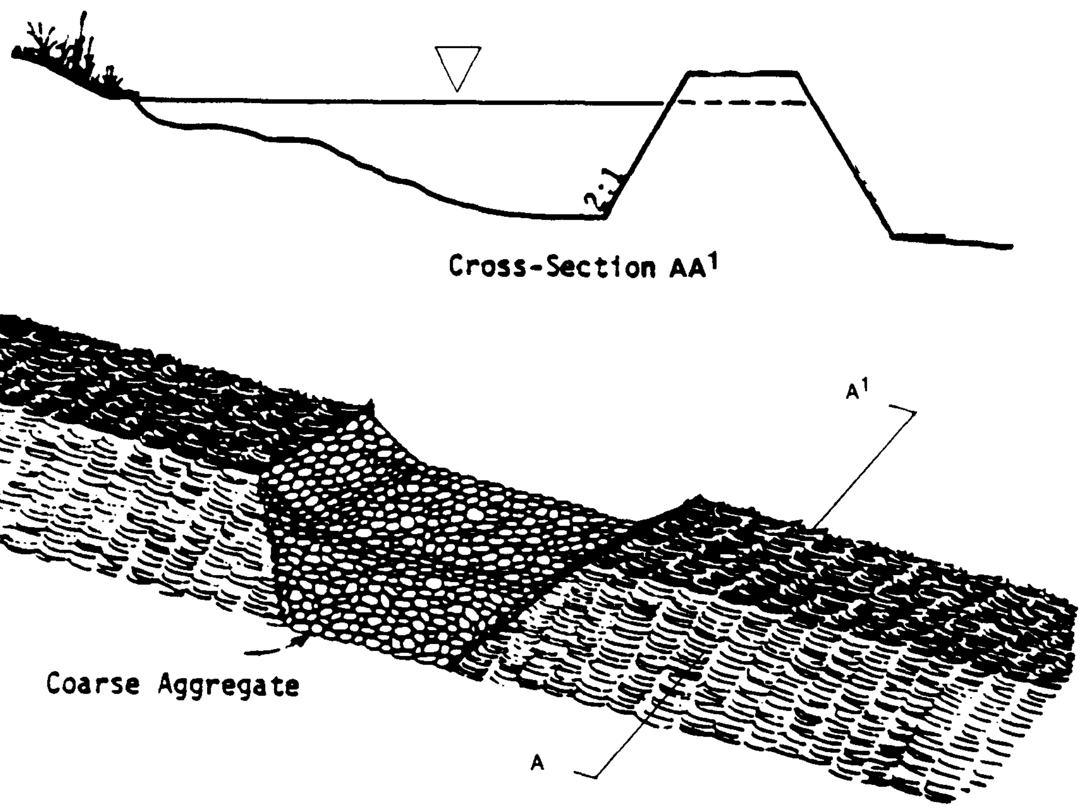


FIGURE 4.25 TYPICAL SEDIMENT TRAP
(Modified from Commonwealth of Virginia, 1980)

When and Where to Use It

A temporary sediment trap may be used in conjunction with other temporary measures, such as gravel construction entrances, vehicle wash areas, slope drains, diversion dikes and swales, or diversion channels. This device is appropriate for sites with short time schedules.

What to Consider

Sediment traps are suitable for small drainage areas, usually no more than 10 acres, that have no unusual drainage features. The trap should be large enough to allow the sediments to settle and should have a capacity to store the collected sediment until it is removed. The volume of storage required depends upon the amount and intensity of expected rainfall and on estimated quantities of sediment in the storm water runoff. Check your Permit to see if it specifies a minimum storage volume for sediment traps.

A sediment trap is effective for approximately 18 months. During this period, the trap should be readily accessible for periodic maintenance and sediment removal. Traps should be inspected after each rainfall and cleaned when no more than half the design volume has been filled with collected sediment. The trap should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place.

Advantages of a Sediment Trap
• Protects downstream areas from clogging or damage due to sediment deposits • Is inexpensive and simple to install • Can simplify the design process by trapping sediment at specific spots onsite
Disadvantages of a Sediment Trap
• Is suitable only for a limited area • Is effective only if properly maintained • Will not remove very fine silts and clays • Has a short life span

Temporary Sediment Basin

What Is It

A temporary sediment basin is a settling pond with a controlled storm water release structure used to collect and store sediment produced by construction activities. A sediment basin can be constructed by excavation or by placing an earthen embankment across a low area or drainage swale. Sediment basins can be designed to maintain a permanent pool or to drain completely dry. The basin detains sediment-laden runoff from larger drainage areas long enough to allow most of the sediment to settle out.

The pond has a gravel outlet or spillway to slow the release of runoff and provide some sediment filtration. By removing sediment, the basin helps prevent clogging of offsite conveyance systems and sediment-loading of receiving waterways. In this way, the basin helps prevent destruction of waterway habitats.

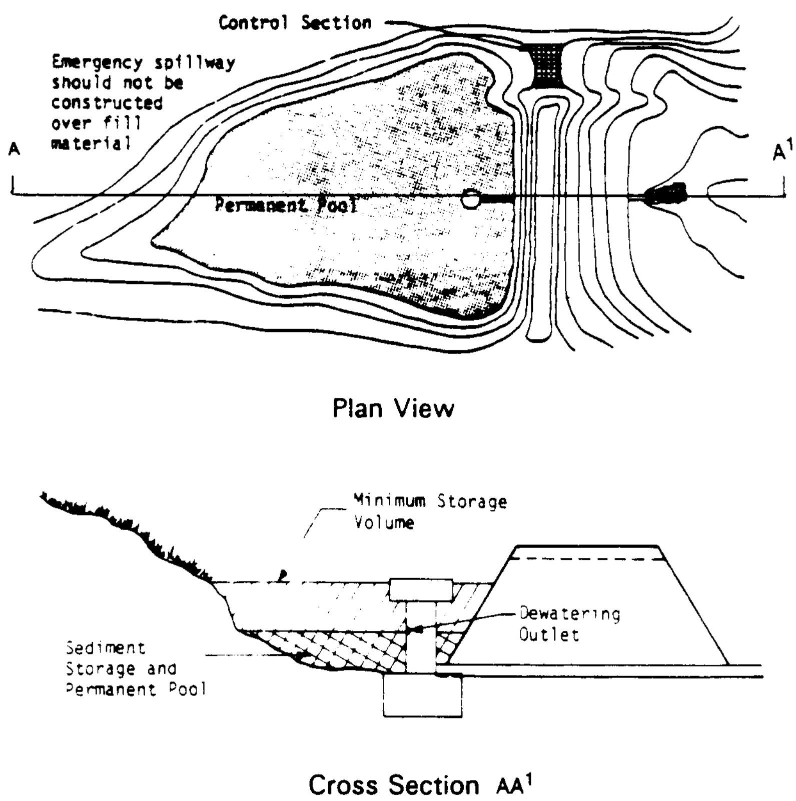


FIGURE 4.26 TEMPORARY SEDIMENT BASIN
(Modified from Commonwealth of Virginia, 1980)

When and Where to Use It

A temporary sediment basin should be installed before clearing and grading is undertaken. It should not be built on an embankment in an active stream. The creation of a dam in such a site may result in the destruction of aquatic habitats. Dam failure can also result in flooding. A temporary sediment basin should be located only where there is sufficient space and appropriate topography. The basin should be made large enough to handle the maximum expected amount of site drainage. Fencing around the basin may be necessary for safety or vandalism reasons.

A temporary sediment basin used in combination with other control measures, such as seeding or mulching, is especially effective for removing sediments.

What to Consider

Temporary sediment basins are usually designed for disturbed areas larger than 5 acres. The pond should be large enough to hold runoff long enough for sediment to settle. Sufficient space should be allowed for collected sediments. Check the requirements of your permit to see if there is a minimum storage requirement for sediment basins. The useful life of a temporary sediment basin is about 12 to 18 months.

Sediment trapping efficiency is improved by providing the maximum surface area possible. Because finer silts may not settle out completely, additional erosion control measures should be used to minimize release of fine silt. Runoff should enter the basin as far from the outlet as possible to provide maximum retention time.

Sediment basins should be readily accessible for maintenance and sediment removal. They should be inspected after each rainfall and be cleaned out when about half the volume has been filled with sediment. The sediment basin should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place. The embankment forming the sedimentation pool should be well compacted and stabilized with vegetation. If the pond is located near a residential area, it is recommended for safety reasons that a sign be posted and that the area be secured by a fence. A well built temporary sediment basin that is large enough to handle the post construction runoff volume may later be converted to use as a permanent storm water management structure.

Advantages of a Temporary Sediment Basin
• Protects downstream areas from clogging or damage due to sediment deposits generated during construction activities • Can trap smaller sediment particles than sediment traps can because of the longer detention time
Disadvantages of a Temporary Sediment Basin
• Is generally suitable for small areas • Requires regular maintenance and cleaning • Will not remove very fine silts and clays unless used in conjunction with other measures • Is a more expensive way to remove sediment than several other methods • Requires careful adherence to safety practices since ponds are attractive to children

Outlet Protection

What Is It

Outlet protection reduces the speed of concentrated storm water flows and therefore it reduces erosion or scouring at storm water outlets and paved channel sections. In addition, outlet protection lowers the potential for downstream erosion. This type of protection can be achieved through a variety of techniques, including stone or riprap, concrete aprons, paved sections and settling basins installed below the storm drain outlet.

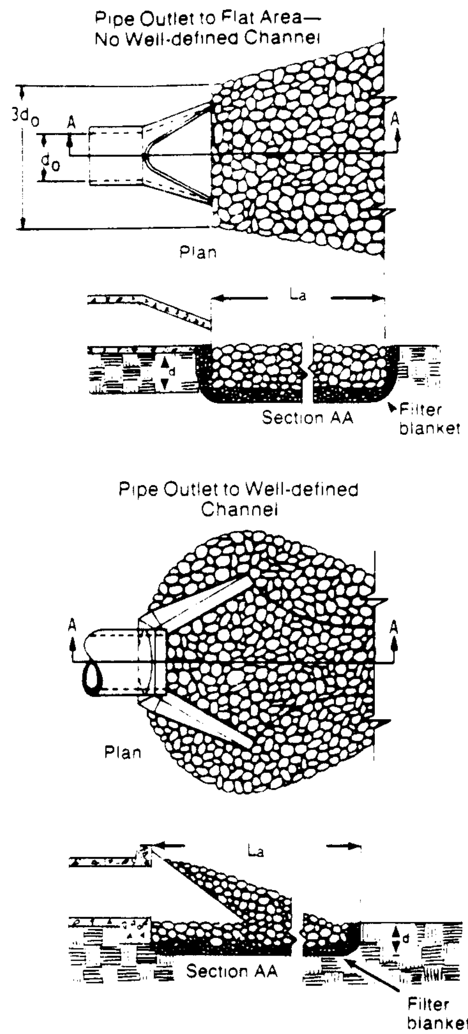


FIGURE 4.27 TYPICAL DETAILS FOR ROCK OUTLET PROTECTION (Modified from State of North Carolina, 1988)

When and Where to Use It

Outlet protection should be installed at all pipe, interceptor dike, swale, or channel section outlets where the velocity of flow may cause erosion at the pipe outlet and in the receiving channel. Outlet protection should also be used at outlets where the velocity of flow at the design capacity may result in plunge pools (small permanent pools located at the inlet to or the outfall from BMPs). Outlet protection should be installed early during construction activities, but may be added at any time, as necessary.

What to Consider

The exit velocity of the runoff as it leaves the outlet protection structure should be reduced to levels that minimize erosion. Outlet protection should be inspected on a regular schedule to look for erosion and scouring. Repairs should be made promptly.

Advantages of Outlet Protection
• Provides, with riprap-line apron (the most common outlet protection), a relatively low cost method that can be installed easily on most sites • Removes sediment in addition to reducing flow speed • Can be used at most outlets where the flow speed is high • Is an inexpensive but effective measure • Requires less maintenance than many other measures
Disadvantages of Outlet Protection
• May be unsightly • May cause problems in removing sediment (without removing and replacing the outlet protection structure itself) • May require frequent maintenance for rock outlets with high velocity flows

Check Dams

What Are They

A check dam is a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows. Reduced runoff speed reduces erosion and gullying in the channel and allows sediments and other pollutants to settle out.

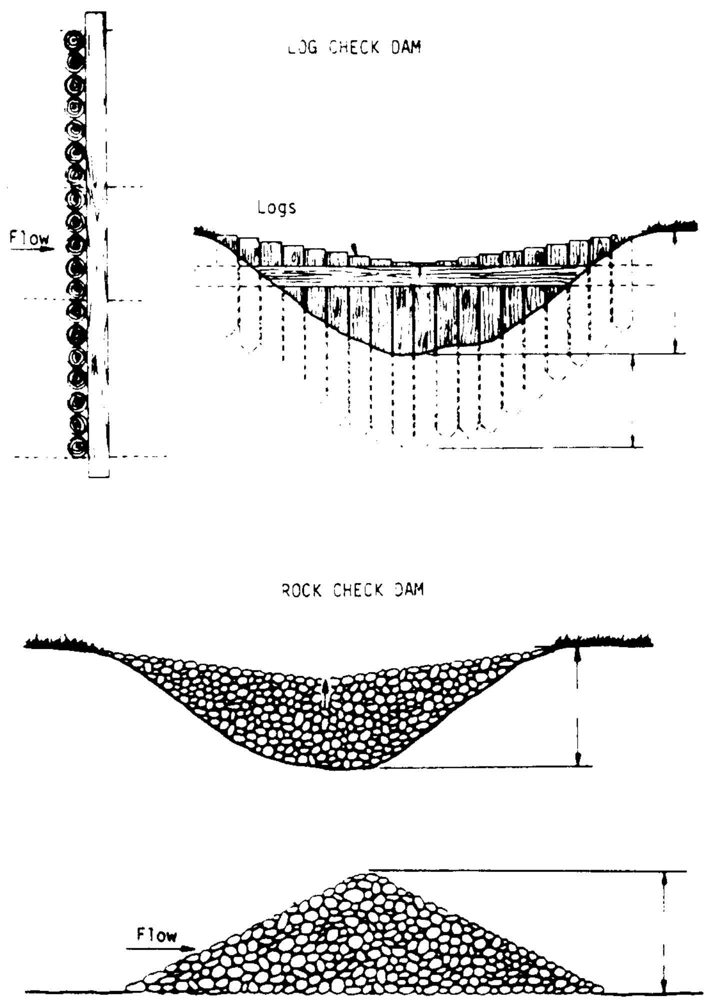


FIGURE 4.28 TYPICAL CHECK DAMS
(Modified from Commonwealth of Virginia, 1980)

When and Where to Use Them

A check dam should be installed in steeply sloped swales, or in swales where adequate vegetation cannot be established. A check dam may be built from logs, stone, or pea gravel-filled sandbags.

What to Consider

Check dams should be used only in small open channels that drain 10 acres or less. The dams should not be placed in streams (unless approved by appropriate State authorities). The center section of the check dam should be lower than the edges. Dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

After each significant rainfall, check dams should be inspected for sediment and debris accumulation. Sediment should be removed when it reaches one half the original dam height. Check for erosion at edges and repair promptly as required. After construction is complete, all stone and riprap should be removed if vegetative erosion controls will be used as a permanent erosion control measure. It will be important to know the expected erosion rates and runoff flow rate for the swale in which this measure is to be installed. Contact the State/local storm water program agency or a licensed engineer for assistance in designing this measure.

Advantages of Check Dams
• Are inexpensive and easy to install • May be used permanently if designed properly • Allow a high proportion of sediment in the runoff to settle out • Reduce velocity and provide aeration of the water • May be used where it is not possible to divert the flow or otherwise stabilize the channel
Disadvantages of Check Dams
• May kill grass linings in channels if the water level remains high after it rains or if there is significant sedimentation • Are useful only for drainage areas of 10 acres or less

Surface Roughening

What Is It

Surface roughening is a temporary erosion control practice. The soil surface is roughened by the creation of horizontal grooves, depressions, or steps that run parallel to the contour of the land. Slopes that are not fine-graded and that are left in a roughened condition can also control erosion. Surface roughening reduces the speed of runoff, increases infiltration, and traps sediment. Surface roughening also helps establish vegetative cover by reducing runoff velocity and giving seed an opportunity to take hold and grow.

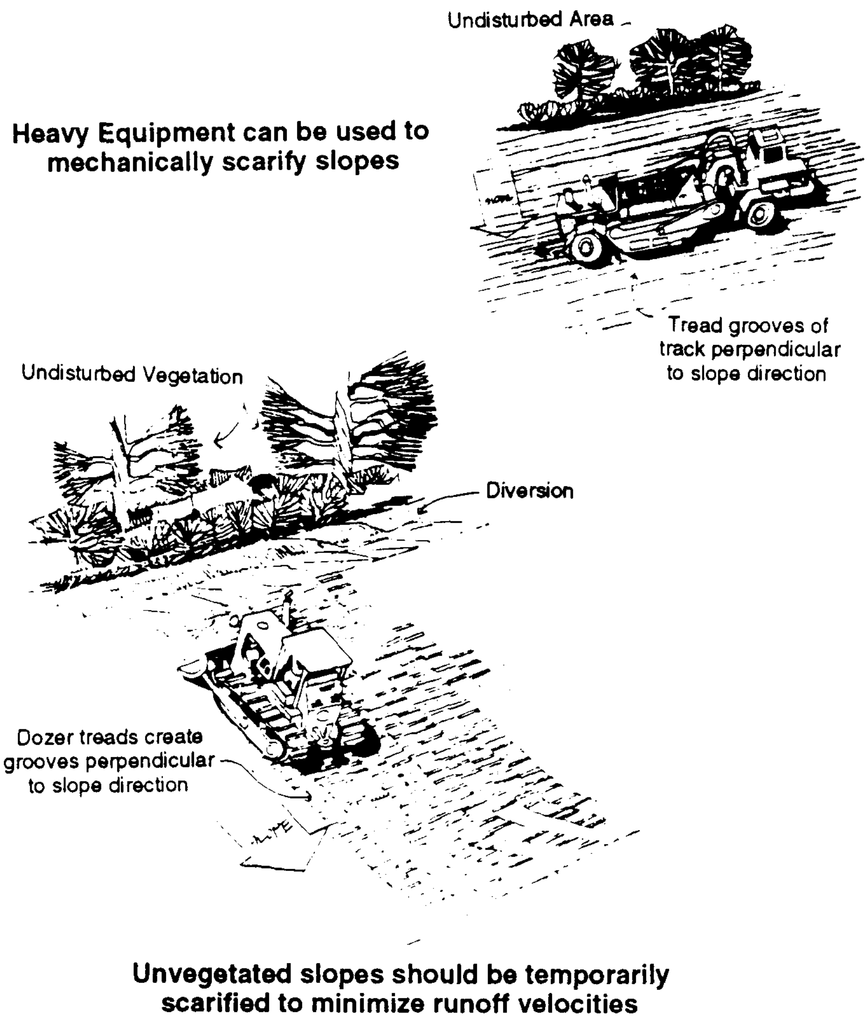


FIGURE 4.29 SURFACE ROUGHENING
(Modified from Washington State, 1992)

When and Where to Use It

Surface roughening is appropriate for all slopes. To slow erosion, roughening should be done as soon as possible after the vegetation has been removed from the slope. Roughening can be used with both seeding and planting and temporary mulching to stabilize an area. For steeper slopes and slopes that will be left roughened for longer periods of time, a combination of surface roughening and vegetation is appropriate.

What to Consider

Different methods can be used to roughen the soil surface on slopes. They include stair-step grading, grooving (using disks, spring harrows, or teeth on a front-end loader), and tracking (driving a crawler tractor up and down a slope, leaving the cleat imprints parallel to the slope contour). The selection of an appropriate method depends on the grade of the slope, mowing requirements after vegetative cover is established, whether the slope was formed by cutting or filling, and type of equipment available.

Cut slopes with a gradient steeper than 3:1 but less than 2:1 should be stair-step graded or groove cut. Stair-step grading works well with soils containing large amounts of small rock. Each step catches material discarded from above and provides a level site where vegetation can grow. Stairs should be wide enough to work with standard earth moving equipment. Grooving can be done by any implement that can be safely operated on the slope, including those described above. Grooves should not be less than 3 inches deep nor more than 15 inches apart. Fill slopes with a gradient steeper than 3:1 but less than 2:1 should be compacted every 9 inches of depth. The face of the slope should consist of loose, uncompacted fill 4 to 6 inches deep that can be left rough or can be grooved as described above, if necessary.

Any cut or filled slope that will be mowed should have a gradient less than 3:1. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together (less than 10 inches) and not less than 1 inch deep. Any gradient with a slope greater than 2:1 should be stair-stepped.

It is important to avoid excessive compacting of the soil surface, especially when tracking, because soil compaction inhibits vegetation growth and causes higher runoff speed. Therefore, it is best to limit roughening with tracked machinery to sandy soils that do not compact easily and to avoid tracking on clay soils. Surface roughened areas should be seeded as quickly as possible. Also, regular inspections should be made of all surface roughened areas, especially after storms. If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be filled, graded again, and reseeded immediately. Proper dust control procedures should be followed when surface roughening.

Advantages of Surface Roughening
• Provides a degree of instant erosion protection for bare soil while vegetative cover is being established • Is inexpensive and simple for short-term erosion control
Disadvantages of Surface Roughening
• Is of limited effectiveness in anything more than a gentle rain • Is only temporary; if roughening or vegetative cover is washed away in a heavy storm or the vegetation does not take hold, the surface will have to be re-roughened and new seed laid

Gradient Terraces

What Are They

Gradient terraces are earth embankments or ridge-and-channels constructed with suitable spacing and with an appropriate grade. They reduce erosion damage by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion.

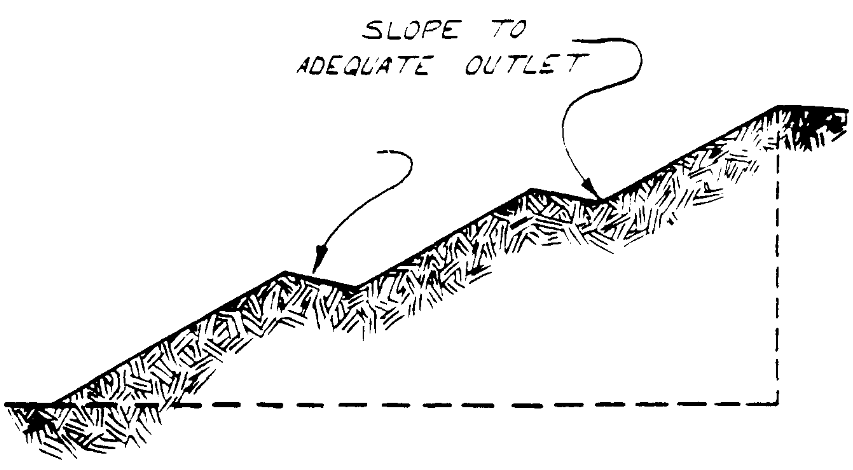


FIGURE 4.30 GRADIENT TERRACE
(Washington State, 1992)

When and Where to Use Them

Gradient terraces are usually limited to use on land that has no vegetation and that has a water erosion problem, or where it is anticipated that water erosion will be a problem. Gradient terraces should not be constructed on slopes with sandy or rocky soils. They will be effective only where suitable runoff outlets are or will be made available.

What to Consider

Gradient terraces should be designed and installed according to a plan determined by an engineering survey and layout. It is important that gradient terraces are designed with adequate outlets, such as a grassed waterway, vegetated area, or tile outlet. In all cases, the outlet should direct the runoff from the terrace system to a point where the outflow will not cause erosion or other damage. Vegetative cover should be used in the outlet where possible. The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow. Terraces should be inspected regularly at least once a year and after major storms. Proper dust control procedures should be followed while constructing these features.

Advantages of Gradient Terraces
• Reduce runoff speed and increase the distance of overland runoff flow • Hold moisture better than do smooth slopes and minimize sediment loading of surface runoff
Disadvantages of Gradient Terraces
• May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates the soil • Are not practical for sandy, steep, or shallow soils

4.6 INFILTRATION PRACTICES

Infiltration practices are surface or subsurface measures that allow for quick infiltration of storm water runoff. Rapid infiltration is possible because the structures or soils used in these practices are very porous. Infiltration practices offer an advantage over other practices in that they provide some treatment of runoff, preserve the natural flow in streams, and recharge ground water. Many of the infiltration practices also can reduce the velocity of the runoff so that it will not cause damaging erosion. Another benefit of infiltration practices is that they reduce the need for expensive storm water conveyance systems. Construction and maintenance of these practices may, however, require some level of expertise to prevent clogging and to retain high effectiveness. The infiltration practices in this section have been divided into two categories: vegetative infiltration practices and infiltration structures.

Infiltration BMPs are not practical in all cases. These practices should not be used in areas where runoff is contaminated with pollutants other than sediment or oil and grease. Excessively drained (i.e., very sandy) soils may provide inadequate treatment of runoff, which could result in ground water contamination. Other site-specific conditions, such as depth to bedrock or depth to the water table, could limit their use or make it impossible to use infiltration BMPs. Also, infiltration practices should not be installed near wells, foundations, septic tank drainfields, or on unstable slopes.

Vegetative infiltration practices rely on vegetated soils that are well drained to provide storage for the infiltration of storm water. Soils used for this practice generally have not previously been disturbed or compacted so that they more easily allow infiltration. Once vegetation has been planted, use of the area must be limited or the practice may not operate efficiently. The practices that are discussed include vegetated filter strips, grassed swales, and level spreaders.

Infiltration structures are built over soils to aid in collection of storm water runoff and are designed to allow storm water to infiltrate into the ground. These structures generally require a level of expertise for both their design and construction so that they function properly. Maintenance activities are very important because infiltration structures are easily damaged by high sediment loads. Often, infiltration structures are used with other structures that pretreat the storm water runoff for sediments, oil, and grease. These pretreatment structures may be as simple as a buffer zone (see Buffer Zones) or may be something more complex, such as an oil and grease separator. The types of infiltration structures discussed include infiltration trenches, porous pavements, concrete grids, and modular pavements.

Vegetated Filter Strips

What Are They

Vegetated filter strips are gently sloping areas of natural vegetation or are graded and artificially planted areas used to provide infiltration, remove sediments and other pollutants, and reduce the flow and velocity of the storm water moving across the terrain. Vegetated filter strips function similarly to vegetated or grassed swales. The filter strips, however, are fairly level and treat sheetflow, whereas grassed swales are indentations (see section on Grassed Swales) and treat concentrated flows. Vegetated filter strips provide permanent storm water control measures on a site.

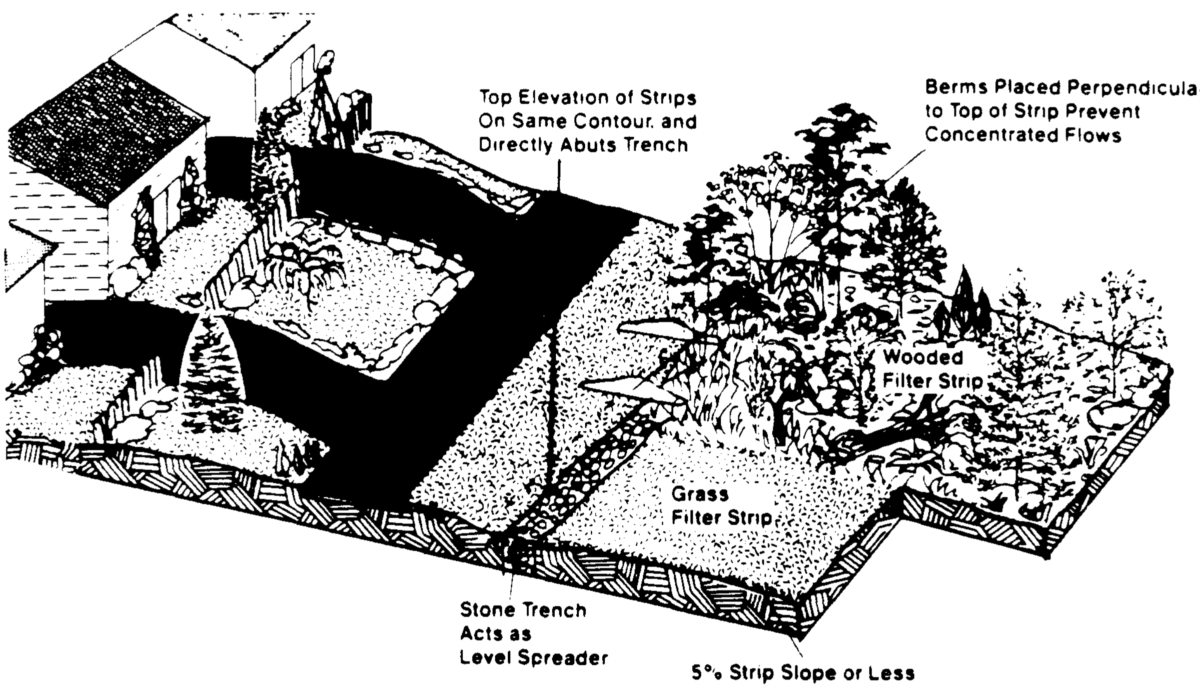


FIGURE 4.31 USE OF FILTER STRIPS (Modified from MWCOG, 1987)

When and Where to Use Them

Vegetated filter strips are suited for areas where the soils are well drained or moderately well drained and where the bedrock and the water table are well below the surface. Vegetated filter strips will not function well on steep slopes, in hilly areas, or in highly paved areas because of the high velocity of runoff. Sites with slopes of 15 percent or more may not be suitable for filtering storm water flows. However, they should still be vegetated (MWCOG, 1987). This practice can be put into place at any time, provided that climatic conditions allow for planting.

What to Consider

At a minimum, a filter strip must be approximately 20 feet wide to function well. The length of the strip should be approximately 50 to 75 feet. Where slopes become steeper, the length of the strip must be increased. Forested strips are always preferred to vegetated strips, and existing vegetation is preferred to planted vegetation. In planning for vegetated strips, consider climatic conditions, since vegetation may not take hold in especially dry and/or cold regions.

Regular inspections are necessary to ensure the proper functioning of the filter strips. Removing sediments and replanting may be necessary on a regular basis. The entire area should be examined for damage due to equipment and vehicles. Vegetation should be dense. Also, the portions of the strip where erosion may have created ponding of runoff should be inspected. This situation can be eliminated by grading.

Advantages of Vegetated Filter Strips
• Provide low to moderate treatment of pollutants in storm water while providing a natural look to a site • Can provide habitat for wildlife • Can screen noise and views if trees or high shrubs are planted on the filter strips • Are easily constructed and implemented • Are inexpensive
Disadvantages of Vegetated Filter Strips
• Are not effective for high velocity flows (large paved areas or steep slopes) • Require significant land space • May have a short useful life due to clogging by sediments and oil and grease

Grassed Swales

What Are They

Grassed swales are vegetated depressions used to transport, filter, and remove sediments. Grassed swales control high runoff rates by reducing the speed of the runoff and by reducing the volume of the runoff through infiltration of the storm water. Pollutants are removed because runoff travels slowly and infiltrates into the soil and because the vegetation in the grassed swale works as a filter or strainer.

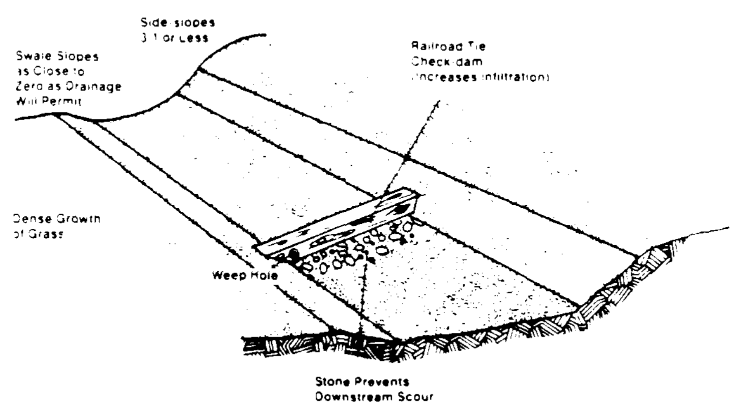


FIGURE 4.32 GRASSED SWALE WITH RAILROAD TIE CHECK DAM (Modified from MWCOG, 1987)

When and Where to Use Them

Grassed swales are suitable for most areas where storm water runoff is low. Certain factors will affect the operation of grassed swales, including soil type, land features, and the depth of the soil from the surface to the water table (i.e., the top of the drenched portion of the soil or bedrock layer). The soil must be permeable for runoff to be able to infiltrate well. Sandy soils will not hold vegetation well nor form a stable channel structure. Steep slopes will increase runoff rates and create greater potential for erosion. Storm water flows will not be easily absorbed where the water table is near the surface. Swales are most useful for sites smaller than 10 acres (MWCOG, 1987). Even without highly permeable soils, swales reduce velocity and thus are useful.

Grassed swales usually do not work well for construction runoff because the runoff has high sediment loads.

What to Consider

The channel of the swale should be as level as possible to maximize infiltration. Side slopes in the swale should be designed to no steeper than 3:1 to minimize channel erosion (MWCOG, 1987). Plans should consider (1) the use of existing topography and existing drainage patterns and (2) the highest flow rate that is expected from a typical storm to determine the most practical size for the swale (in keeping with State or local requirements).

The swale should be tilled before grass is planted, and a dense cover of grasses should be planted in the swale. The location of the swale will determine the best type of vegetation (e.g., if the swale runs next to a road, then the grass chosen should be resistant to the use of de-icing salts in northern states).

Check dams (i.e., earthen or log structures) may be installed in the swales to reduce runoff speed and increase infiltration. Planners should also consider the design of the outlet at the end of the swale so that the runoff is released from the swale at a low rate (see section on Outlet Protection).

Maintenance activities for the swales include those practices needed to maintain healthy, dense vegetation and to retain efficient infiltration and movement of the storm water into and through the swale. Periodic mowing, reseeding, and weed control are required to maintain pollutant removal efficiency. The swale and channel outlet should be kept free from sediment buildup, litter, brush, or fallen tree limbs.

Periodic inspections will identify erosion problems or damaged areas. Damaged or eroded areas of the channel should be repaired. Areas with damaged vegetation should be reseeded immediately.

Advantages of Grassed Swales

- Are easily designed and constructed
- Provide moderate removal of sediments if properly constructed and maintained
- May provide a wildlife habitat
- Are inexpensive
- Can replace curb and gutter systems
- Can last for long periods of time if well maintained

Disadvantages of Grassed Swales

- Cannot control runoff from very large storms
- If they do not drain properly between storms, can encourage nuisance problems such as mosquitos, ragweed, dumping, and erosion
- Are not capable of removing significant amounts of soluble nutrients
- Cannot treat runoff with high sediment loadings

Level Spreaders

What Are They

Level spreaders are devices used at storm water outlets to spread out collected storm water flows into sheetflow (runoff that flows over ground surface in a thin, even layer). Typically, a level spreader consists of a depression in the soil surface that spreads the flow onto a flat area across a gentle slope. Level spreaders then release the storm water flow onto level areas stabilized by vegetation to reduce speed and increase infiltration.

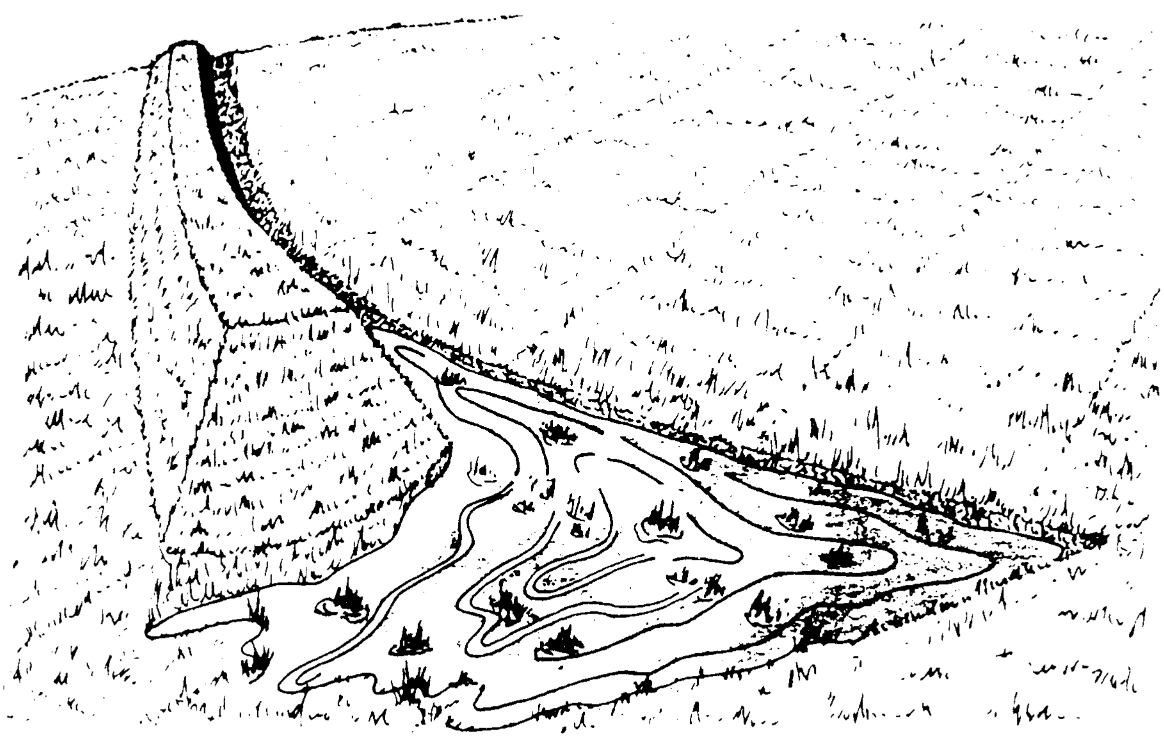


FIGURE 4.33 LEVEL SPREADERS
(Modified from Commonwealth of Virginia, 1990)

When and Where to Use Them

Level spreaders are most often used as an outlet for temporary or permanent storm water conveyances or dikes. Runoff that contains high sediment loads should be treated in a sediment trapping device prior to release into a level spreader.

What to Consider

The length of the spreader depends upon the amount of water that flows through the conveyance. Larger volumes of water need more space to even out. Level spreaders are generally used with filter strips (see Vegetated Filter Strips). The depressions are seeded with vegetation (see Permanent Seeding).

Level spreaders should not be used on soil that might erode easily. They should be constructed on natural soils and not on fill material. The entrance to the spreader should be level so that the flow can spread out evenly.

The spreader should be inspected after every large storm event to check for damage. Heavy equipment and other traffic should be kept off the level spreader because these vehicles may compact the soil or disturb the grade of the slope. If ponding or erosion channels develop, the spreader should be regraded. Dense vegetation should be maintained and damaged areas reseeded as needed.

Advantages of Level Spreaders
• Reduce storm water flow velocity, encourage sedimentation and infiltration • Are relatively inexpensive to install
Disadvantages of Level Spreaders
• Can easily develop "short circuiting" (concentration of flows into small streams instead of sheetflow over the spreader) because of erosion or other disturbance • Cannot handle large quantities of sediment-laden storm water

Infiltration Trenches

What Are They

An infiltration trench usually consists of a long, narrow excavation ranging from 3 to 12 feet deep. The trench is filled with stone, which allows for temporary storage of storm water runoff in the open spaces between the stones. The stored storm water infiltrates into the surrounding soil or drains into underground pipes through holes and is then routed to an outflow point. Infiltration trenches are designed to remove both fine sediments and soluble pollutants rather than larger, coarse pollutants.

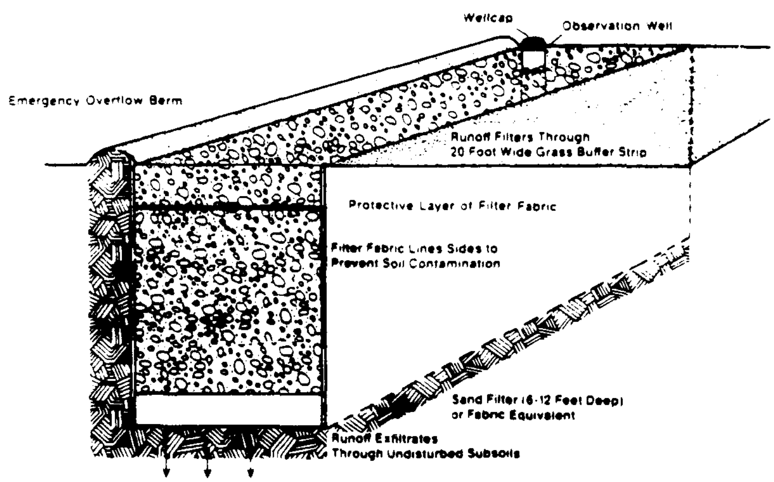


FIGURE 4.34 TYPICAL INFILTRATION TRENCH
(Modified from MWCOG, 1987)

When and Where to Use Them

Infiltration trenches should be restricted to areas with certain soil, ground water, slope, area, and pollutant conditions. For example, infiltration trenches will not operate well in soils that have high clay contents, silt/clay soils, sandy/clay loams, or soils that have been compacted. Trenches should not be sited over fill soils because such soils are unstable. Hardened soils are often not suitable for infiltration trenches because these types of soils do not easily absorb water. Infiltration practices in general should not be used to manage contaminated storm water.

The drainage area contributing runoff to a single trench should not exceed 5 acres (State of Maryland, 1983). Construction of trenches should not start until after all land-disturbing activities have ceased so that runoff with high levels of sediment does not fill in the structure.

If slopes draining into the trench are steeper than 5 percent, the runoff will enter the trench too fast and will overwhelm the infiltration capacity of the soil, causing overflow. The depth from the bottom of the trench to the bedrock layer and the seasonal high water table must be at least three feet. Infiltration trenches may not be suitable in areas where there are cold winters and deep frost levels.

What to Consider

Pretreatment of runoff before it is channeled to the trench is important to efficient operation because pretreatment removes sediment, grit, and oil. Reducing the pollutant load in the runoff entering the trench lengthens trench life. One method of pretreatment is to install a buffer zone just above the trench to act as a filter (see Buffer Zones). In addition, a layer of filter fabric 1 foot below the bottom of the trench can be used to trap the sediments that get through the buffer strip. If excavation around the trenches is necessary, the use of light duty equipment will avoid compacting, which could cause a loss of infiltration capability.

Infiltration trenches should be inspected at least once per year and after major rainfall events. Debris should be removed from all areas of the trench, especially the inlets and overflow channels. Dense vegetative growth should be maintained in buffer areas surrounding the trench.

Test wells can be installed in every trench to monitor draining times and provide information on how well the system is operating. Daily test well monitoring is necessary, especially after large storm events. If the trench does not drain after 3 days, it usually means that the trench is clogged.

Advantages of Infiltration Trenches
• Preserve the natural water balance of the site • Are effective for small sites • Remove pollutants effectively
Disadvantages of Infiltration Trenches
• Require high maintenance when sediment loads are heavy • Have short life span, especially if not maintained properly • May be expensive (cost of excavation and fill material)

Porous Pavements/Concrete Grids and Modular Pavements

What Are They

Porous pavement, concrete grids, and modular pavements allow storm water to infiltrate so that the speed and amount of runoff from a site can be reduced.

Porous Pavement–Can be either asphalt or concrete. With porous asphalt pavement, runoff infiltrates through a porous asphalt layer into a stone "reservoir" layer. Storm water runoff filters through the stone reservoir into the underlying subsoil or drains into underground pipes through holes and is routed away. The bottom and sides of the stone reservoir are lined with filter fabric to prevent the movement of soils into the reservoir area.

Porous Concrete Pavement–Is made out of a special concrete mix that has a high number of open spaces between the particles and a coarse surface texture. These open spaces allow runoff to pass through the surface to lower levels. This type of pavement can be placed directly on graded soils. When a subbase is used for stability, 6 inches of sand is placed under the concrete mixture. Up to 6 inches of storm water can be held on the surface of the pavement and within the concrete.

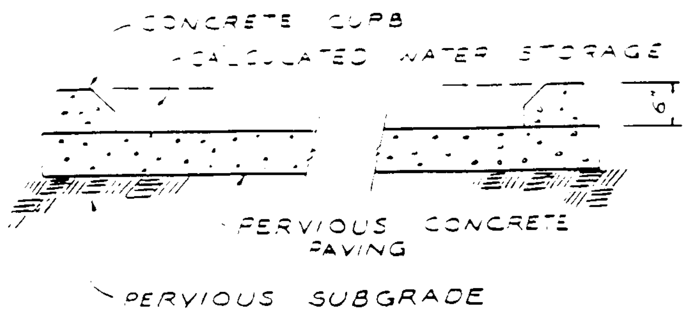
Concrete Grids and Modular Pavement–Are made out of precast concrete, poured-in-place concrete, brick, or granite. These types of pavements can also reduce the loading and concentration of pollutants in the runoff. Concrete grids and modular pavements are designed and/or constructed so that they have open spaces within the pavement through which storm water can infiltrate into the ground. These open spaces can be filled with gravel or sand or have vegetation growing out of them.

When and Where to Use Them

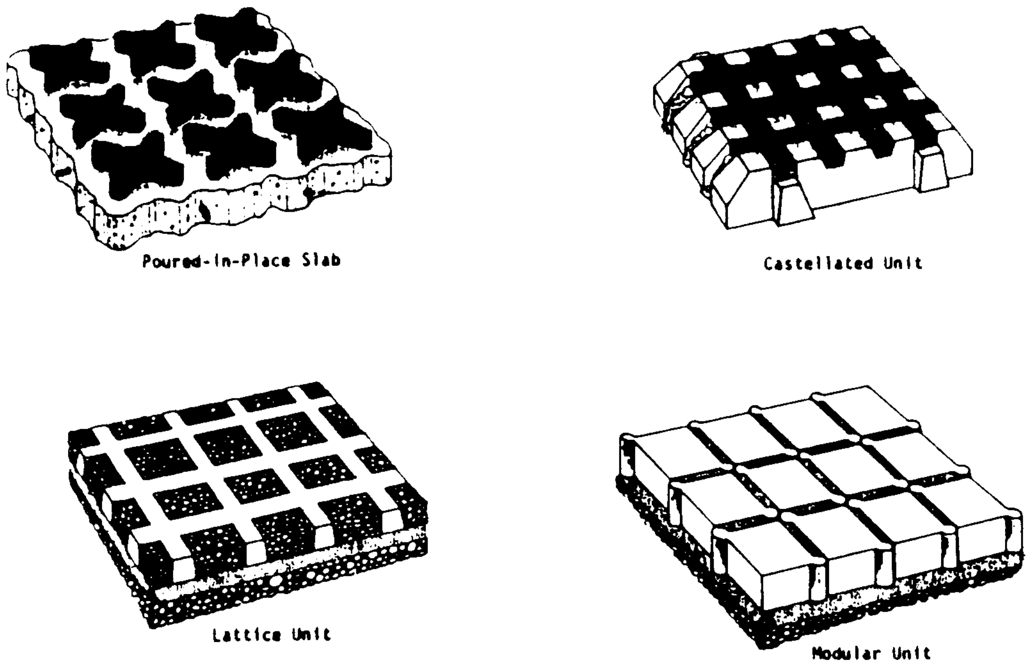
These structures are usually only suitable for low-volume parking areas (1/4 acre to 10 acres) (State of Maryland, 1983) and lightly used access roads. However, areas that are expected to get moderate or high volumes of traffic or heavy equipment can use conventional pavements (for the heavy traffic areas) that are sloped to drain to areas with the porous pavements. These pavements are not effective in drainage areas that receive runoff containing high levels of sediment.

The soil types over which concrete grids and modular pavement are to be placed should allow for rapid drainage through the pores in the pavement. These pavements are not recommended for sites with slopes steeper than 5 percent (MWCOG, 1987) or sites with high water tables, shallow bedrock, fill soils, or localized clay lenses, which are conditions that would limit the ability of the runoff to infiltrate into surface soils. For example, the water table and bedrock should be at least 3 feet below the bottom of the stone reservoir. Porous pavement will not operate well in windy areas where sediment will be deposited on the porous pavement.

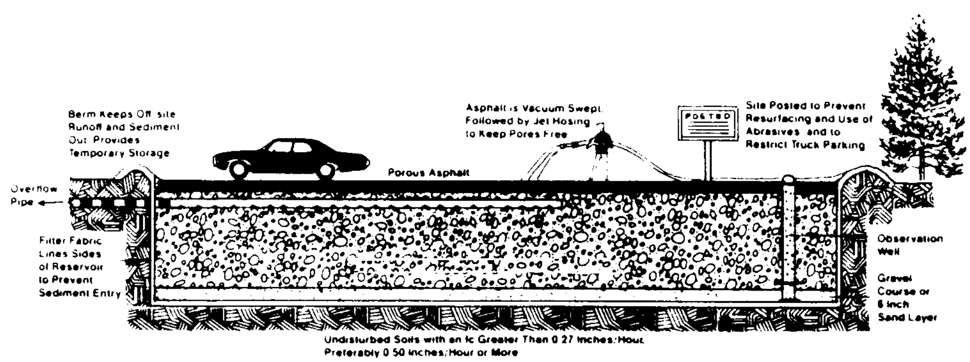
Construction of these pavements should be timed so that installation occurs on the site after other construction activities are finished and the site has been stabilized. Therefore, sediments are less likely to be tracked or carried on to the surface.



Detail of Pervious Concrete Pavement



Types of Grid and Modular Pavements



Cross Section of Porous Asphalt Pavement

FIGURE 4.35 POROUS PAVEMENTS, CONCRETE GRIDS, AND MODULAR PAVEMENTS
(Modified from Commonwealth of Virginia, 1980; MWCOG, 1987; and Washington State, 1992)

What to Consider

Proper installation of these pavements requires a high level of construction expertise and workmanship. Only contractors who are familiar with the installation of these pavements should be used.

Designers of porous pavement areas should consider sediment and erosion control. Sediments must kept away from the pavement area because they can clog the pores. Controls to consider for sediments include a diversion berm (i.e., earthen mound) around the edge of the pavement area to block the flow of runoff from certain drainages onto the pavement, or other filtering controls such as silt fences. De-icing salt mixtures, sands, or ash also may clog pores and should not be used for snow removal. Signs should be posted to prohibit these activities.

Since the infiltration of storm water runoff may contaminate ground water sources, these pavements are not suitable for areas close to drinking water wells (at least 100 feet away is recommended) (State of Maryland, 1983).

Maintenance of the surface is very important. For porous pavements, this includes vacuum sweeping at least four times per year followed by high-pressure hosing to reduce the chance of sediments clogging the pores of the top layer. Potholes and cracks can be filled with typical patching mixes unless more than 10 percent of the surface area needs repair. Spot clogging may be fixed by drilling half-inch holes through the porous pavement layer every few feet.

The pavement should be inspected several times the first few months after installation and then annually. Inspections after large storms are necessary to check for pools of water. These pools may indicate clogging. The condition of adjacent vegetated filter strips, silt fences, or diversion dikes should also be inspected.

Concrete grids and modular pavements should be designed in accordance with manufacturers' recommendations. Designers also need information on soils, depth to the water table, and storm water runoff quantity and quality.

Maintenance of concrete grids and modular pavements is similar to that of the porous pavements; however, turf maintenance such as mowing, fertilizing, and irrigation may be needed where vegetation is planted in the open spaces.

Advantages of Porous Pavements/Concrete Grids and Modular Pavements
• Provide erosion control by reducing the speed and quantity of the storm water runoff from the site • Provide some treatment to the water by removing pollutants • Reduce the need for curbing and storm sewer installation and expansion • Improve road safety by providing a rougher surface • Provide some recharge to local aquifers • Are cost effective because they take the place of more expensive and complex treatment systems
Disadvantages of Porous Pavements/Concrete Grids and Modular Pavements
• Can be more expensive than typical pavements • Are easily clogged with sediment and/or oil; however, pretreatment and proper maintenance will prevent this problem • May cause ground water contamination • Are not structurally suited for high-density traffic or heavy equipment • Asphalt pavements may break down if gasoline is spilled on the surface • Are less effective when the subsurface is frozen